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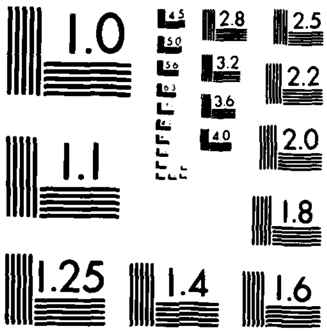
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COMPUTERS FOR COMMAND AND CONTROL:

AN AIRLAND BATTLE REQUIREMENT!

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTERS OF MILITARY ART AND SCIENCE

by

JOSEPH W. MC KINNEY, MAJOR, USA
B.S., United States Military Academy, 1970

Fort Leavenworth, Kansas
1984

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A152 742	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) COMPUTERS FOR COMMAND AND CONTROL: AN AIRLAND BATTLE REQUIREMENT!		5. TYPE OF REPORT & PERIOD COVERED MASTERS THESIS
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) JOSEPH W. MCKINNEY		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Command and General Staff College ATTN: ATZL-SWD-GD Fort Leavenworth, Kansas 66027		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE MAY 1984
		13. NUMBER OF PAGES 157
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

COMPUTER, MICROCOMPUTER, MCS, TCS, TCT, SPADS, AIDS, AIRLAND BATTLE, COMMAND, CONTROL, COMMAND AND CONTROL, C2, C3, C3I, COMMAND POST, CORPS

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Airland Battle doctrine places extensive requirements on the corps command and control system. However, C2 procedures have changed little since WWII. It is questionable whether the current system, based on manual information processing, can satisfy the doctrinal requirements.

Microcomputer based systems can enhance communications, improve data management, and support decision making through information display (SEE REVERSE)

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20. ABSTRACT (Continued)

and mathematical modeling.

This thesis examines the current and potential utility of microcomputer systems to support command and control of corps maneuver forces in the near term (1984-1990).

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THESIS APPROVAL PAGE

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Accepted this 16th day of May 1984 by Philip J. Brookes,
Director, Graduate Degree Programs.

The opinions and conclusions addressed herein are those of the student author and do not necessarily reflect the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

COMPUTERS FOR COMMAND AND CONTROL: AN AIRLAND BATTLE REQUIREMENT!, by Major Joseph W. McKinney, USA, 149 pages.

Airland Battle doctrine places extensive requirements on the corps command and control system. In order to adhere to doctrinal tenets (Initiative, Depth, Synchronization, Agility) the corps must be capable of rapidly analyzing a high volume of information inputs, determining optimal courses of action, and transmitting clear and appropriate directives to subordinate units. However, command and control procedures at corps level have changed little since World War II. It is questionable whether the current command and control system can satisfy doctrinal requirements.

Microcomputer systems are currently used in civilian organizations to improve communications, enhance data management, and support decision making through graphical display techniques and mathematical models. It is logical to assume that microcomputers can be used to perform similar functions in tactical units.

This thesis will examine the current and potential utility of microcomputer systems to support command and control of corps maneuver forces in the near term (1984-1990).

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INTRODUCTION

Throughout history, victory in battle has frequently been gained by the leader who proved most capable in commanding his forces. Prior to World War I, command was usually exercised through personal presence on the battlefield. The commander would position himself where he could best view the action. From that location he would issue orders or, if required, move to the decisive point on the battlefield and lead his forces in person. In this century the nature and characteristics of warfare have changed. Larger armies now fight on a greatly extended and much more lethal battlefield. A senior commander has little opportunity either to view the entire battlefield or to influence the action by personal example. Instead, he must manage and direct the action through a complex command and control system. This thesis will explore the command and control system, the requirements placed upon the system by both U.S. doctrine and the reality of the modern battlefield, and the capability of modern microcomputer technology to enhance the system.

I. BACKGROUND: COMMAND, CONTROL, AND COMPUTERS

The term "command and control" is subject to wide latitude in interpretation. Frequently, writers stress the human, or leadership, aspect of command and control. Other sources emphasize the procedural aspects of command and control. A third group accents the importance of technical systems (usually communications related). Therefore, in order to examine the role of microcomputers within the realm of tactical command and control, it is first necessary to define the term and develop its parameters.

The U.S. Army has adopted a fairly comprehensive definition of command and control. FM 101-5-1, Operational Terms and Graphics, defines it as:

> Functions performed through the arrangement of personnel, equipment, communications, facilities, and procedures which provide for the direction of combat operations.(1)

A more comprehensive definition is contained in Joint Chiefs of Staff (JCS) Publication 1, Dictionary of Military and Associated Terms.

> The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and

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1. U.S. Army. Operational Terms and Graphics. FM 101-5-1, March 1980, p. 1-27.

> procedures which are employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.(2)

From examination of these definitions, it is relatively easy to divide command and control into three interrelated elements: organization, processes, and facilities. These three elements constitute a command and control system.(3) Specifically, JCS Pub 1 defines the command and control system as:

> The facilities, equipment, communications, procedures, and personnel essential to a commander for planning, directing and controlling operations of assigned forces pursuant to the missions assigned.(4)

A key point in the JCS definition is that the command and control system supports the commander. It is the mechanism by which he exercises command and control over his forces.

In addition to defining command and control, it is necessary to describe the nature of the term in relation to the tactical environment. This can be accomplished through examination of the three elements cited above: organization, processes, and facilities.

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2. Department of Defense. Dictionary of Military and Associated Terms. JCS Publication 1, 1 June 1979, p. 74.
3. U.S. Army CGSC. Fundamentals of Command and Control. (Fort Leavenworth, Kansas, 1983), p. 1-4.
4. Department of Defense. Dictionary of Military and Associated Terms. JCS Publication 1, 1 June 1979, p. 74.

The organizational element of command and control consists essentially of a commander and a staff. The commander has always been the central figure in command and control. All other aspects (other personnel, equipment, facilities, communications, and procedures) are designed to aid the commander in analyzing, deciding, and directing. Naturally, the commander is afforded great flexibility in tailoring his command and control system. The traditional role of the staff has been to free the commander from mundane tasks not associated with "fighting" his organization. Staffs at one time were limited almost exclusively to personnel and supply specialists (Adjutant and Quartermaster, respectively). A major development in modern armies is the increased size of the operational staff. At corps and division level, staffs have grown appreciably in size in order to cope with the increasing complexity of war. This is particularly true in the areas of operations (G3), intelligence (G2) and combat support (field artillery and air support). Also included in the organizational element of command and control is the communication structure necessary to support the commander and the staff. Units have organic tactical VHF and HF radios with limited local wire capability. In addition, common user communications support is provided by a signal brigade at corps level and a signal battalion at division level. Principal means of communication (from both organic and supporting sources) are wire, several types of of radio systems, and courier.

The process element of command and control is the embodiment of the internal procedures by which the commander and the staff operate. It includes receiving, distributing, processing, and analyzing information in support of staff estimates for the commander. It further includes the preparation and dissemination of the commander's decisions in the form of guidance, orders, directives, or priorities. Normally procedures are developed locally by each organization and included in the unit standing operating procedure (SOP). Procedures are usually flexible in order to accommodate personnel changes within the organization and changes in the operational environment (particularly changes in the availability of time).

The facilities element of command and control includes the equipment and the accommodations which physically support the command and control system. Normally, units exercise command and control from three command posts. These are a main command post (Main CP), a tactical command post (TAC CP), and a rear command post (Rear CP). The Rear CP is generally used for the management and coordination of logistical support, not for tactical command and control. Distribution of functions between the other two CPs is a matter of local policy. However, the TAC CP is usually a small, mobile facility located well forward on the battlefield. From it the commander can control current operations. The Main CP is normally located in the rear area of the unit (out of enemy cannon artillery range). It contains the bulk of the staff and is the hub for coordination with adjacent units and higher headquarters, planning of future operations, and intelligence activities. Either command post can be established in a variety of configurations. Units frequently use a combination of tents, expansible vans, tracked vehicles, and buildings (depending upon availability).

In response to increased capabilities of Soviet/Warsaw Pact forces to detect and attack command post facilities, several organizations have begun experimenting with alternatives to the traditional Main CP/TAC CP configuration. One concept is the dispersed command post. Essentially, it entails breaking the Main CP down into several small modules and dispersing them as required by the situation (up to approximately fifteen kilometers from one another). Dispersal would increase with the intensity of the conflict and with the probability of the employment of nuclear weapons. The effectiveness of a dispersed command post is dependent upon sound operating procedures and reliable means of communication. In addition, enhanced information processing capabilities are essential to compensate for the potential lack of face-to-face communication.

The Army has long recognized the potential of computers as an aid in the exercise of tactical command and control. A Signal Corps study in 1956 developed the architecture for Command Control Information System 1970 (CCIS-70), an Army-wide system which included sub-systems for operations, intelligence, and fire support down to corps and division levels.(5) This recognition of potential, however, did not result in the the rapid development and fielding of automated systems to support the tactical commander. The first automated battlefield system, the Field Artillery Digital Automated Computer (FADAC) was fielded in 1962.(6) Since that time several

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5. William N. Martasin, "The Integration of Tactical and Administrative Automatic Data Processing Systems in the United States Army," thesis, U.S. Army War College, 1964, pp. 33-35.

6. Alexander Ross, "Tactical Automation: The Achilles Heel of the US Army," Armed Forces Journal International, February 1981, p. 46.

other automated systems have been fielded for specialized functions, but the number of fielded systems has not been nearly what would have been anticipated. Significantly, no automated system has been fielded to support the tactical commander's control of maneuver forces.

There are many reasons for the Army's apparent inability to develop and field these systems. Among the major reasons are the following:

a. The rate of change in computer technology has been great. The Army's research, development, and acquisition (RDA) process has been unable to adapt to that rate. Consequently, embryonic systems become outdated in the RDA process and never reach the field. As one source noted, "The RDA system is not geared to fielding systems that mature and become obsolete in months rather than years."(7)

b. The Army did not, early on, develop a consistent, comprehensive, and long term management plan for the integrated development and fielding of automated tactical systems. Systems management has been

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7. Bernard L. Verdier and David P. Porreca, "The Command and Control Systems of the Future - Now," _Military Review,_ November 1981, p. 64.

vertical. Horizontal coordination among agencies has been limited. Consequently developmental systems have proliferated, costs have increased, and integration has been lacking.(8)

c. Difficulties have been experienced in the identification of operational requirements for tactical systems. There are two factors which have contributed to these difficulties. First, commanders and staff officers in the field have not been routinely queried on operational requirements as part of the systems development process. Instead, perceived requirements have frequently been generated by personnel within the project management structure. As a consequence, systems have been designed with functions that do not actually assist the commander or staff. Second, commanders and staff officers, unfamiliar with the capabilities and limitations of computer systems, have had difficulty in adequately stating their requirements.(9)

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8. Alexander Ross, ".Tactical Automation: The Achilles Heel of the US Army?," Armed Forces Journal International, February 1981, pp. 44-15.

9. William J. Hilsman, "Design and Operation of an Automated Command and Control System," (staff paper, U.S. Army Command and General Staff College, 1966), p. 15-16.

In recent years, steps have been taken to alleviate some of the deficiencies noted above. The Army has recognized that computer systems designed to support command and control must satisfy requirements generated by the operational environment. Therefore, close and continuous coordination with tactical commanders and staff officers during development is essential. Involvement of tactical units in the development and testing of systems has increased. This is perhaps best illustrated by the evolutionary development approach for the Maneuver Control System (MCS) with VII Corps in Europe.(10)

Today the use of automated systems for tactical command and control is expanding rapidly within the Army. As mentioned above, MCS is being used in VII Corps. In addition, other units are using developmental systems based on commercial, off-the-shelf hardware and contractor written software. The Army Command and Control Initiatives Program (TACIP), a Training and Doctrine Command project, has encouraged (and funded) tactical unit experimentation

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10. For a description of the benefits of evolutionary development, see Alan B. Salisbury, Project Manager, OPTADS, "MCS: The Maneuver Control System," Signal, March 1982, pp. 35-39.

with available technology for command and control enhancement. A major challenge facing the Army today is to capture the lessons of experimentation in the field in order to rapidly develop an effective system for the future.

II. AIRLAND BATTLE DOCTRINE

Any study of modern command and control must be made against the backdrop of doctrine. The doctrinal requirements for modern combat are reflected in the current operational concept for the Army. This concept, termed Airland Battle Doctrine is based upon four fundamental tenets which are reviewed below.(11)

INITIATIVE: U.S. Army forces must strive to maintain independence of action. Conversely, the enemy must be denied the opportunity to freely select and execute the tactical options which are to his advantage. In order to maintain the initiative, tactical units must be able to act more quickly than the enemy forces

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11. U.S. Army. Operations. FM 101-5. August 1982, pp. 2-2, 2-3.

opposing them.

DEPTH: In past wars, most emphasis has been placed on fighting and winning the close-in battle between opposing forces in close contact with one another. Airland Battle doctrine emphasizes fighting a battle in depth, from the unit rear boundary through enemy follow-on echelons. U.S units must be capable of simultaneously fighting three interrelated and inseparable actions. These are the Rear Battle against enemy elements targeted on key terrain and facilities in rear areas, the Close-In Battle against enemy units in proximity to the Forward Line of Own Troops (FLOT), and the Deep Battle against enemy follow-on forces not yet committed at the FLOT. Depth on the battlefield is bi-dimensional, being measured in both time and distance, and is influenced by the factors of METT-T (Mission, Enemy, Terrain, Troops Available, and Time). (12) The concept of depth also encompasses the

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12. There are three operational terms associated with depth and terrain management on the battlefield. An Area of Influence is that area within which a unit can influence operations through maneuver and fire support. An Area of Operations (AO) is that area, designated by higher headquarters, in which a unit conducts operations. The higher headquarters considers a subordinate unit's Area of Influence when it determines that unit's AO. The Area of Interest is that area about which the unit is concerned. The Area of Interest is generally larger than the AO, extending beyond the rear, forward, and lateral boundaries. As an example, a corps may be assigned an AO that extends 150 km beyond the FLOT. This AO, given available air support, may be roughly equivalent to the corps' Area of Influence. However, the corps may establish an Area of Interest extending 300 km beyond the FLOT in order to provide time for target development and operational planning.

management of current and anticipated resources, including combat, combat support, and combat service support assets.

AGILITY: Agility is an abstract concept that melds two requirements: speed and flexibility. Units must be capable of reacting rapidly to avoid enemy strengths and to attack enemy weaknesses. Units must be capable of departing from existing plans in order to take advantage of opportunities as they develop. The scope of initiative, in this regard, is bounded by a thorough understanding of the intent of the higher commander. Agility requires rapid, dynamic decision making, coupled with positive command and control during execution. Essentially, units must be able to act faster than their enemy can react in order to accomplish their mission and fulfill the commander's intent.

SYNCHRONIZATION: Synchronization is the coordinated employment of all elements of combat power in a unified, comprehensive operation to fulfill the intent of the commander. It includes the deep battle well beyond the FLOT, the close-in battle at the FLOT, rear area operations, employment of reserves, management of logistical assets, employment of nuclear and chemical weapons when authorized, and continuous planning for future operations.

Essentially, Airland Battle doctrine requires commanders to attack the enemy through the depth of his formations, bring about and accept close combat on favorable terrain with acceptable combat power ratios, and employ reserves at the decisive time to complete the destruction of the enemy. To fulfill these requirements, the commander must analyze large amounts of information from a variety of sources. Based upon that analysis, he must make timely and tactically correct decisions. He must then rapidly transmit those decisions to subordinate leaders who are at distant locations. The challenge for the modern commander is to be able to perform this process -analyze, decide, direct- faster and more effectively than his opposing commander.

III. THESIS STATEMENT

Airland Battle doctrine has energized thinking and study on the operational level of war. The operational level of war, characterized by campaign planning and execution, falls between strategic policy making and tactical execution. Operational art may be practiced by theater armies, army groups, and corps.(13) Within the Army, the focus for doctrinal development has thus far been the corps. At corps level, operations must be planned and executed in accordance with Airland Battle principles (initiative, depth, agility, synchronization). Operational effectiveness is highly dependent upon the quality of command and control within tactical organizations. The nature of the Airland Battlefield necessitates rapid information assessment and effective decision making within the command and control system.

Achieving greater speed and effectiveness in information processing and decision making is a major challenge facing tactical commanders today. Existing technology, particularly in the field of microcomputers, can assist the commander in meeting that challenge. The purpose of this thesis is to assess the utility of microcomputer systems to support command and control of corps maneuver forces in the near term (1984-1990).

This thesis includes a description of current microcomputer based systems used for command and control within corps command posts, and an assessment of

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13. U.S. Army. Corps Operations. FM 100-15 (Coordinating Draft). March 9, 1982, p. 1-5.

capabilities those, and projected systems can provide to the commander in the near future. Recommendations on the design and functional capabilities of near-term microcomputer systems are developed. Further, since computers are only one element of the command and control system, recommendations on organizational/procedural integration are provided where appropriate.

IV. RESEARCH METHODOLOGY

There are no sources available which provide a general overview of microcomputer systems as tactical command and control aids. Therefore, a variety of other types of materials have been reviewed for this paper. These include test reports, after action reports from unit field exercises, studies conducted for the Army by outside agencies, papers prepared by students at military schools, and articles in periodicals and journals. These types of materials, while providing large amounts of detailed information, frequently do not put that information in perspective. Therefore, input has been solicited from individuals involved in the fields of both tactical command and control and microcomputer support for tactical command and control.

Significantly, no statistical data have been collected to support this thesis. Therefore quantitative analysis has not been possible and all conclusions are, of necessity, subjective.

V. SCOPE AND LIMITATIONS

As stated in previous paragraphs, the focus of this thesis is the examination of microcomputer based systems for tactical command and control. Given the broad definition of "command and control," systems being fielded for the management of artillery fire support, intelligence collection, air defense, and other battlefield functions could be included. However, examination in this thesis of all such systems would not be manageable. Therefore the scope is further limited to microcomputer systems to support command and control of _maneuver_ at _corps_ level.

This thesis is not intended to be a scientific paper. However, engineering specifications and technical performance standards are important. They, where appropriate for inclusion in this paper, have been translated into non-technical terms which should be more easily understood by the general reader.

The material contained in this thesis is limited to unclassified information. Most classified references pertain to the threat against United States command and control systems or to specific situational employment of developmental computer systems. Therefore the exclusion of classified material is not considered significant given the purpose of the thesis.

VI. THESIS OUTLINE

The remaining chapters of the thesis are described below.

Chapter Two is a review of the source material which contributed to the thesis. It highlights references which were particularly useful and which may be of further interest to the reader.

Chapter Three is a description of the microcomputer systems currently in use and which were considered in the thesis. It includes the user experiences with the systems, intended functions of the systems, and degree to which the systems have been integrated into the command and control structure to date. Detailed discussion of each system's configuration, hardware, and software are contained in appendices. The three systems discussed are:

-The Maneuver Control System, which has been tested in VII Corps and has recently been approved for Army-wide fielding.

-The Automated Information Distribution System (AIDS), a microcomputer graphics system also being tested in VII Corps.

-The Staff Planning and Decision Support System (SPADS), a system initially fielded for testing in V Corps and now also being used in XVIII Airborne Corps.

Chapter Four is an assessment of the current effectiveness of microcomputer systems in supporting command and control. This assessment is performed in two steps. First the requirements placed upon the command and control system by Airland Battle doctrine and the characteristics of the modern battlefield are developed. Second, the demonstrated functional performances of systems previously discussed in Chapter Three are examined. In addition, potential functional capabilities for the near term are hypothesized. The information derived from this assessment provides the basis for the final chapter.

Chapter Five provides the conclusions derived from this research. In addition, recommendations concerning microcomputer system configuration, functional capabilities, and integration have been provided. The conclusions and recommendations, together, address the primary thesis question: "How can microcomputer systems improve the command and control of corps maneuver forces in the near term?"

CHAPTER 2

REVIEW OF LITERATURE

As stated in the preceding chapter, no comprehensive published sources on the use of computers for tactical command and control were found during the research effort which supported this thesis. Most material which was reviewed was devoted to command and control in general, a single facet of command and control, or a specific technical area. This necessitated a certain amount of selectivity in extracting and sorting facts, hypotheses, and other information. To support the thesis, source material was divided into several topics: the nature of command; background; doctrine; current systems description; command and control requirements; microcomputer systems performance/potential; and general information. The purpose of this chapter is to review for the reader the major sources of information in each of those categories.

I. THE NATURE OF COMMAND AND CONTROL

A wealth of information has been published on the subject of command. Many authors have attempted to grasp the essence of command by examining the personalities and actions of successful leaders. Others have taken a more technical approach, attempting to analyze command in regard to models, functional interactions, and psychology. Although a major study of the nature of command was beyond the scope of this thesis, some research was necessary in order to "set the stage." Three sources proved to be both interesting and useful in preparing this thesis. First, S.L.A. Marshall in his well known book, Men Against Fire, touches on the problems of command and control on the modern battlefield and warns against an over reliance on modern technology. He states that, "The diabolical effect of even such a relatively simple instrument as the field telephone is that it may come to command the commander. It chains him to a system of remote control."(1) The "Art and Requirements of Command" study, a four volume work prepared by the Franklin Institute Research Laboratories for the Director of Special Studies, Office of the Chief of Staff, Army in 1967, provided useful insight into how command and

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1. S.L.A. Marshall, Men Against Fire, (Gloucester, MA, Peter Smith, 1978), p. 102.

control has been exercised in the past. Of particular interest were Volume II of the study, which contains results of questionnaires administered to numerous WWII combat leaders, and Volume IV, a composite portrait of a commander based upon historical studies. Finally, a study prepared by Mr. Virgil Ney of the Combat Operations Research Group for the U. S. Army Combat Developments Command, "The Evolution of Military Unit Control 500BC - 1965AD," gave an interesting overview of the development of military organizations and their relationship with weaponry, tactics, and leadership. A thread which runs through these sources, and United States Army command philosophy in general, is that commanders must frequently position themselves well forward with the fighting units in order to effectively assess, direct, and lead.

II. BACKGROUND: COMPUTERS FOR COMMAND AND CONTROL

Background information in Chapter One alluded to difficulties that have been experienced by the Army in fielding tactical computer systems in the past. A CGSC staff paper prepared by Major William J. Hilsman (now Lieutenant General and Director of the Defense Communications Agency) in 1966, "The Design and Operation of an Automated Command and Control System," examines the problems associated with the definition of requirements. That same problem, and its solution via evolutionary development of the MCS, is described in an article in the March 1982 issue of Signal, "MCS: The Maneuver Control System," by Colonel Alan B. Salisbury. Insight into the organizational problems associated with systems fielding was provided by Mr. Alexander Ross' article in the February 1981 issue of Armed Forces Journal International, "Tactical Automation: The Achilles Heel of the US Army?" This topic, the difficulties associated with the development and fielding of automated battlefield systems, received only cursory attention since it was only ancillary to the thesis question. It is, however, one area that definitely warrants further study, particularly in light of the increasing proliferation of tactical computer systems Army-wide.

III. DOCTRINE: COMMAND AND CONTROL ON THE AIRLAND BATTLEFIELD

The doctrinal foundations for this thesis were provided by U.S. Army Field Manual 101-5, Operations, which is the capstone of the "How to Fight" manuals. Particularly pertinent information was provided in three subject areas. First, Chapter One describes the challenges facing the Army on the modern battlefield. Second, Chapter Two describes operational concept for Airland Battle doctrine. Third, Chapter Two also contains a description of concepts that are termed "combat imperatives." A clear understanding of the tenets of Airland Battle, elements of combat power, and imperatives of modern combat is essential in order to accurately determine the requirements for microcomputer system support of command and control. Additional doctrinal information was provided by TRADOC Pamphlet 525-5, "The Airland Battle and Corps 86." This pamphlet was published early in the Army's transition to Airland Battle doctrine. It includes, among other topics, a detailed rationale for the emphasis on deep attack at corps level, and a brief analysis of corps command and control requirements. Another TRADOC Pamphlet, 525-2, "Tactical Command and Control," provided a useful overview of the command and control system, particularly at division and corps levels. Since the scope of this thesis is limited to command and control of maneuver forces at corps level, U.S. Army Field Manual 100-15, Corps Operations (Coordinating Draft), and the new Field Circular 100-15, naturally proved to be essential doctrinal references.

IV. CURRENT SYSTEMS

Sources used for the description of the three corps level systems examined in the thesis were varied. Each will be covered in detail in the following paragraphs.

Information on the Staff Planning and Decision Support System was mostly drawn from documentation prepared by BDM Corporation in support of the Dispersed Command Post Project. Three separate manuals support SPADS and all were valuable references for this thesis. The "Staff Officer's Manual" contains an overview of both SPADS capabilities and planning considerations for system integration. The "SPADS Operator's Manual" describes how to operate the system. The "Network Manager's Manual" describes the system in detail, including network configuration. All three of these manuals were prepared under contract to Defense Nuclear Agency. Information on the background of SPADS and on system integration problems was drawn from my personal experience as the Dispersed CP Project Officer for V Corps from January 1982 until June 1983.

The description of the Maneuver Control System was extracted from three pamphlets prepared by Librascope Division of The Singer Company. These are "Maneuver Control System," "Tactical Computer System (TCS) AN/UYQ-19," and

"Fully Militarized Tactical Computer Terminal (TCT) AN/UYQ-30." They contain an overview of MCS and detailed descriptions of the TCT and TCS, respectively. All three pamphlets were prepared under U.S. Government contract. The first was prepared for Project Manager, CECOM. The second and third were prepared for Project Manager, CORADCOM. Background information and details on system integration were drawn from two additional sources. The first was an article by Colonel Alan B. Salisbury, "MCS: The Maneuver Control System," in the March 1982 issue of Signal. The second was an interview with Colonel William S. Kromer, TRADOC Systems Manager, SIGMA, conducted at Fort Leavenworth, Kansas.

Documentation on the Automatic Information Distribution System was limited to the TRADOC Combined Arms Test Activity Concept Evaluation Program (CEP) resume sheet. The CEP resume sheet provided a description of the system hardware. Other information was provided by Mr. John Stucker, CACDA-C3I Project Officer, in an interview conducted at Fort Leavenworth.

Other major sources of information on the three systems are described in the other categories within this chapter.

V. REQUIREMENTS

This section pertains to sources which aided in development of requirements for a "generic" command and control computer system. Specific functional requirements for microcomputer enhancement of command and control were difficult to document. The requirements described in this thesis are, therefore, the result of a certain amount of extrapolation and hypothesis.

The foundation for command and control system requirements is naturally the Army's Airland Battle doctrine. For this thesis, that doctrine was applied to a postulated European battlefield. The basic references for doctrine have been cited in Section III, above.

Information processing requirements within the command and control system were examined as an adjunct to the thesis. The "Phase I, Corps Information Flow" study, prepared by TRADOC in 1979, provided a detailed analysis of the corps commander's information needs and the dynamics of information flow to satisfy those needs. A listing of the information elements which were identified in the study is attached as Appendix E. Interesting background material on information flow (and problems in fielding automated systems) was found in "Battlefield Information Reporting System Automated TOC Evaluation," prepared by the V Corps BIRS Task Force in 1979.

The most definitive description of functional requirements for nondevelopmental microcomputer systems for tactical command and control was found in the Operational and Organizational Plan for the Command Post Automated Staff Support (CPASS) System (FINAL DRAFT). This document was distributed by CACDA-C3I in January 1984.

Additional information concerning requirements was provided by tactical units. Corps involved in microcomputer systems testing were queried concerning their experiences and their needs. The information provided by V Corps and XVIII Airborne Corps was most useful, as were comments provided by Brigadier General Thomas H. Tait, G3 of V Corps during the first year of the Dispersed CP Project. General Tait was interviewed at Fort Leavenworth.

VI. PERFORMANCE

The category "performance" included information which documented results of the experimentation on systems to date, and material which described microcomputer capabilities that might be incorporated into future systems. Documentation on performance consisted essentially of reports of evaluations performed by the TRADOC Combined Arms Test Activity (TCATA). TCATA evaluated MCS in conjunction with REFORGER 82 and SPADS in conjunction with WINTEX 83. Correspondence from both V and VII Corps and information drawn from personal experience supplemented the TCATA reports. A concise summary of MCS performance, from the user viewpoint, was provided by a packet which was prepared by VII Corps for the Deputy Under Secretary of the Army (OR). A major source of information on potential developments in command and control systems was Signal, a magazine from which several articles are cited in the bibliography and in notes.

VII. GENERAL SOURCES

Two documents provided by the Army Research Institute Unit at Fort Leavenworth proved most helpful in preparing this thesis. The first, "Final Report - Objective 3, Command Control Group Behaviors," by Roland V. Tiede and Joseph C. Kerner of Science Applications, Inc., examines the conversion from manual command and control systems to ADP supported systems. Their goal is to develop methods for anticipating and controlling turbulence inherent in that conversion process. The report includes an analysis of command and control requirements, a model for command and control decision making, a comparison between business organizations and the military C2 systems, and roles for ADP in the C2 system. The second document, "Guidelines for Automating Command and Control Functions in Field Units," by the Army Research Field Unit, Leavenworth, provides a practical methodology for tactical units to follow for integration of computer systems into the command and control structure. A comparison of human vs. computer capabilities which was contained in the document was most useful, particularly in assessing potential pay-offs resulting from automation. The comparison has been extracted and is provided as Appendix D. Both of these sources, in addition to providing technical background material, aided in efforts to place the supporting computer system into perspective with the overall command and control system.

Two sources provided a general overview of command and control issues (to include automation). The November 1981 issue of Military Review was devoted to the subject of command and control. Although it did not focus specifically on computer systems support, it was found to be a most worthwhile source for background material. A Command and General Staff College text, Reference Book 101-34, Command

and Control on the Airland Battlefield, publisheo by the Command and General Staff College, was an effective "primer" for this thesis. It consists of ninety-nine articles reprinted from a variety of sources. It covers the full spectrum of command and control topics. Both the *Military Review* and the Reference Book are recommended as introductory reading on the subject of command and control.

CHAPTER 3

SYSTEM DESCRIPTIONS

As stated in Chapter One, the purpose of this thesis is to examine the current use of microcomputers in the field of maneuver command and control, and to develop recommendations on how microcomputer based systems can improve command and control in the near term. The scope of the thesis is limited to corps level since corps is the focus for "Operational Art," the crux of Airland Battle doctrine.

Currently there are three corps which are actively involved in the testing and development of microcomputer based command and control systems. Two corps are involved in testing and development of the Staff Planning and Decision Support System, commonly referred to as SPADS. These are V Corps, a forward deployed corps in Europe, and XVIII Airborne Corps, a contingency corps based at Fort Bragg, North Carolina. VII Corps, also a forward deployed corps in Europe, is the test bed for development of the Maneuver Control System (MCS). In addition, VII Corps has supplemented MCS with another microcomputer system, the Automated Information Distribution System (AIDS).

Each of the three microcomputer systems will be described in this chapter. The description will include background, functional capabilities, and a summary of how the microcomputer system has been integrated into the corps command control system. Technical information on SPADS, MCS, and AIDS is provided in Appendices A, B, and C, respectively.

I. STAFF PLANNING AND DECISION SUPPORT SYSTEM

A. Background:

As described in Chapter One, corps have traditionally operated with TAC, MAIN, and REAR command posts. In recent years, several studies have analyzed the vulnerability of command posts in that configuration in the European environment (particularly with regard to the possible employment of nuclear weapons). Alternative command post arrays, designed to enhance the survivability of the command and control system, have been proposed.(1)

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1. Defense Nuclear Agency briefing outline, "Nuclear Survivable C3 Systems for NATO."

One alternative is the "Dispersed Command Post" in which the MAIN CP is divided into several small modules which are separated from each other by up to fifteen kilometers. In late 1980, V Corps began examining the feasibility of dispersing its MAIN CP. Potential shortfalls in the capability to process and distribute information among dispersed modules were identified, hindering concept development. In mid-1981, Defense Nuclear Agency (DNA) proposed using microcomputers to alleviate those shortfalls. Limited computer capabilities were demonstrated during Reforger in September of that year. Subsequently, SPADS, which had been developed by BDM Corporation of McLean, Virginia, was demonstrated at V Corps Headquarters in January, 1982. Based in part upon the demonstrated potential of the system, V Corps agreed to provide a test-bed for development of a conceptual dispersed command post supported by SPADS. Other major participants in the project were DNA, the Army Communicative Technology Office (ACTO), and the TRADOC Combined Arms Development Activity (CACDA). In conjunction with the V Corps project, the 8th Infantry Division (a division subordinate to V Corps) initiated a Concept Evaluation Program (CEP) test with CACDA in February 1982. The CEP focused on command and control at division level on the Airland Battlefield. Another major objective of the CEP was to assess the corps-division interface.(2) The 8th Infantry Division was, therefore, involved early-on in SPADS development and testing.

Since June 1982, SPADS has been used by V Corps during all command post exercises. Joint V Corps/8th Infantry Division testing commenced with Reforger 82 (September 1982) and has continued since that time. As a later development, a SPADS system was deployed with the 3d Armored Division command post during Reforger 1983 (September 1983).

Since December 1981, XVIII Airborne Corps has been experimenting with the use of commercial microcomputers for automation of some command and control functions. In February 1982, XVIII Airborne Corps initiated a CEP test with CACDA to evaluate the use of microcomputers for command and control in their unique operational environment (which includes possible deployment world-wide). Subsequently, they were provided with SPADS equipment for additional concept development and testing. Initial equipment delivery commenced in October 1982. Since then, XVIII Airborne Corps has used SPADS to support their

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2. Combined Arms Center (ATZL-CAC-IA) letter, "8th Infantry Division CEP Resume Sheet," 22 February 1983.

Tactical Information C2 System (TACTICS) and has employed SPADS equipment in their MAIN, TAC, and REAR command posts and in the command posts of their subordinate divisions.

B. System Description:

The SPADS system consists of a number of microcomputer work stations, termed Staff Duty Stations, within each command post module. The Staff Duty Stations are connected via a local area network. The local area networks are interfaced through the supporting tactical communications system so that information can be transferred via data link from one module to another. SPADS software is designed to support database management, data distribution, electronic mail, color graphics, word processing, and tactical information display using video disk generated maps. A detailed description of SPADS software and hardware is provided in Appendix A.

C. System Integration:

Currently there are approximately twenty SPADS Staff Duty Stations at V Corps. These are normally configured on five local area nets within the MAIN and TAC command posts. The 8th Infantry Division has approximately 14 staff duty stations on 4 local nets (2 nets in the MAIN, 1 in the TAC, and 1 in the REAR). XVIII Airborne Corps has approximately ten staff duty stations distributed among its MAIN, TAC, REAR, and supporting Battlefield Coordination Element. In addition, at least one staff duty station is deployed in each subordinate division's MAIN command post. Amounts of SPADS equipment are expected to increase within both V Corps and XVIII Airborne Corps units in the near future as development and testing continue.

II. MANEUVER CONTROL SYSTEM

A. Background:

The roots of the Maneuver Control System can be traced back to the Army's first major endeavor in the field of automatic data processing for tactical command and control enhancement. That program, the Tactical Operation System, or TOS, was conceptualized in 1958 and initially tested in Europe between 1964 and 1969. In 1970 the program was renamed Developmental TOS (DEVTOS) and testing was shifted to MASSTER, Fort Hood, Texas. Testing and development of TOS continued at Fort Hood through 1979. During that period the program received some criticism due to the lengthy developmental process, inadequate requirements definition, and cost. In 1980 the TOS program was significantly realigned under Operations Tactical Data Systems (OPTADS).(3) Essentially, the TOS program was "killed." TOS hardware, however, was retained for a new program, the Maneuver Control System.(4) In addition to changing the name from Tactical Operations System to Maneuver Control System, realignment included changes in both technical design and developmental approach. Of these two areas, the change in developmental approach was most significant.(5) In order to insure that MCS would satisfy the requirements of potential users, an evolutionary developmental approach was adopted. VII Corps and its subordinate units became the test bed for operational evaluation of MCS. This evolutionary development process was characterized by incremental fielding of MCS hardware and software with user evaluation performed in conjunction with field exercises.

Limited amounts of MCS equipment were initially fielded prior to Certain Ramparts, the VII Corps exercise

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3. Alexander Ross, "Tactical Automation: The Achilles Heel of the US Army?," Armed Forces Journal International, February 1981, p. 48.

4. Interview with Colonel William S. Kromer, TRADOC System Manager, SIGMA, Fort Leavenworth, Kansas.

5. Alan B. Salisbury, "MCS: The Maneuver Control System," Signal, March 1982, p. 37.

conducted in conjunction with Reforger in September 1980. During that exercise three Tactical Computer Terminals (TCT) were used to transmit data among VII Corps, 1st Armored Division and 2d Armored Cavalry Regiment. A Tactical Computer System (TCS) was first introduced in Europe in the summer of 1981. Three TCS and seventeen TCT devices were available and used during the Reforger exercise that year.(6) During 1981 and 1982, additional amounts of equipment were progressively fielded to VII Corps. This facilitated both expansion and refinement of the functional capabilities of the system. Carbine Fortress, conducted as part of Reforger in September 1982, featured an extensive network of MCS equipment among VII Corps units. In addition, for the first time TCT links from VII Corps to both V Corps and Central Army Group (CENTAG) were established. Based upon the favorable results of development and testing, funds were approved in 1983 for purchase and operational fielding of the Maneuver Control System.(7)

For the purpose of overall perspective, MCS is a subset of the Army Command and Control Subordinate Systems

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6. Ibid.

7. Headquarters, Department of the Army Message, "Promulgation of MCS ASARC III Decision," 050035Z JAN 84.

(ACCS2). The other systems are Fire Support, Intelligence/Electronic Warfare, Air Defense, and Combat Service Support. SIGMA is the name of the Army project charged with defining and developing the interfaces between the five subsets.(8)

B. System Description:

Currently the Maneuver Control System consists of a network of militarized mini and microcomputers. There are three principal components, the Tactical Computer System (TCS), the Tactical Computer Terminal (TCT), and the Analyst Console. These components, in varying configurations, are distributed among the corps command posts and subordinate unit command posts. Both the TCS and the TCT are capable of stand-alone operations. The Analyst Console is essentially an input/output terminal remoted from a TCS. The TCS, which is the most powerful component, can provide central storage for a network of TCTs and Analyst Consoles. The network can be achieved via either military tactical communications systems (multichannel, VHF FM voice radio, etc) or by "hard wiring." In a recent development in MCS evolution, commercial hardware will be

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8. Interview with Colonel William S. Kromer, TRADOC System Manager, SIGMA, Fort Leavenworth, Kansas.

integrated into the production system when it is fielded. Study into which commercial, or non-developmental items (NDI), will be procured is ongoing at the present time.(9) The MCS is designed to support database management, message preparation and distribution, and tactical information display. A diagram of anticipated MCS network configuration and detailed hardware and software descriptions are provided in Appendix B.

C. System Integration:

Thus far, MCS integration has been essentially limited to evolutionary development experiences. During field exercises, its primary utility has been as a device for message preparation and information distribution. This feature has allowed VII Corps to partially overcome what has been termed the "tyranny of the message center." Development is continuing on the database system and other software capabilities. It can be anticipated that the functional integration of MCS will continue to increase, particularly since fielding of MCS has been approved. A total of 234 TCTs, 53 TCSs, and 19 Analyst Consoles will be purchased by the Army. Figures for amounts of

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9. Headquarters, Department of the Army Message, "Promulgation of MCS ASARC III Decision, 050035Z JAN 84.

Non-Developmental Items which will be incorporated into MCS are not available at this time.

IV. AUTOMATIC INFORMATION DISTRIBUTION SYSTEM

A. Background:

As described in the preceding section, VII Corps has used the Maneuver Control System primarily to enhance information transfer between echelons of command (corps to division). To enhance information transfer within the corps command post structure, VII Corps has employed the Automatic Information Distribution System (AIDS).

The development of AIDS was prompted by a perceived requirement for more rapid and effective information exchange to support both staff planning and the commander's decision making process.(10) VII Corps had been experimenting with a cellular command post concept which had exacerbated problems with information distribution. As a solution, VII Corps proposed to achieve enhanced performance via a microcomputer distribution system with

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10. VII Corps briefing outline," Automated Information Distribution System."

decision graphics capability. Subsequently, AIDS was provided to VII Corps by TRADOC under the provisions of a Concept Evaluation Plan (CEP). Equipment deliveries began in September 1982. The first major field test of AIDS was conducted in conjunction with Exercise WINTEX 83 (March 1983). AIDS was fully operational within the scope of the concept by September 1983.

B. System Description:

AIDS consists of a number of commercial microcomputer work stations (termed Remote Processors) which are linked to a more powerful microcomputer (Central Processor). The microcomputers can be interfaced either on a local area network or from distant locations via modems and the tactical communications system. The major function of the system is to support decision making through enhanced information display. Software is provided to facilitate color graphics preparation, distribution, and presentation. A detailed description of AIDS software and hardware is contained in Appendix C.

C. System Integration:

Currently there is one AIDS Central Processor, which is employed at the VII Corps MAIN CP. There are 10

Remote Processors, 6 at the MAIN, 1 at the TAC, and 3 at the REAR. The six at the MAIN are connected to the Central Processor via a local area net. The Remote Processors at the TAC and REAR interface with the Central Processor via acoustic modems over the tactical communications system. This configuration essentially satisfies the system concept as outlined in the Concept Evaluation Plan.

Thus far, VII Corps has concentrated on using AIDS to support the corps commander's informational requirements with decision graphics. The required information is configured in the form of an electronic briefing. This use, while satisfying the CEP requirement, does not fully utilize the inherent capabilities of AIDS microcomputers. Since AIDS Remote and Central Processors use the CP/M Operating System, AIDS can be used to run a variety of commercial programs. Some of these programs might have applications related to the exercise of command and control. Work is continuing at the corps on development of database management applications, particularly on the automatic conversion of data from tabular to graphic form.(11)

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11. Interview with John Stucker, CACDA C3I, Fort Leavenworth, Kansas, 12 December 1983.

V. SUMMARY

The previous three paragraphs contain brief descriptions of SPADS, MCS, and AIDS, respectively. There is some overlap in functional capabilities among all three systems. Each, however, is the result of a different approach to providing enhanced command and control. SPADS is a multifunctional system which is designed to satisfy diverse requirements from the commander or staff through commercially available hardware and software. MCS is designed to support command and control at several echelons (brigade to corps with links to echelons above corps). MCS has fewer functions than SPADS, but is more durable in a battlefield environment. AIDS is designed for one major function, to support planning and decision making with automated information distribution and decision graphics.

The effectiveness of each system in enhancing maneuver command and control will be examined in the following chapter.

CHAPTER 4

AIRLAND BATTLE REQUIREMENTS / COMPUTER CAPABILITIES

In this chapter, the current effectiveness and potential utility of each of the three corps microcomputer C2 systems (SPADS, MCS, and AIDS) will be assessed. This assessment will be performed in two steps. First, the requirements placed on the command and control system by both doctrine and the the battlefield environment will be developed. Additionally, those requirements will be translated into specific functions within the command and control process. Then the potential for microcomputer systems to enhance the performance of those functions will be analyzed. For each function, the current performance and future potential of existing systems will be determined. This evaluation will provide the basis for information contained in the final chapter, Conclusions and Recommendations.

I. COMMAND AND CONTROL ON THE AIRLAND BATTLEFIELD

The tenets of Airland Battle doctrine: initiative, depth, agility, and synchronization, were defined in Chapter One. These tenets, integrated into a comprehensive operational concept, will have a profound impact on how the Army will fight in the future. While the concept may appear simple, it presupposes a number of complex activities. The Army must develop and field systems which permit the commander to see and to attack in depth. Forces must be organized and equipped so that they are capable of responding with the required agility. In addition, a command and control system must be developed which can take advantage of improved collection and maneuver capabilities to effect a synchronized total effort. The doctrinal requirements for the corps command and control system will be developed in this paragraph.

DEPTH: FM 100-5 defines depth in terms of distance, time, and resources. As a result of Airland Battle doctrine, the corps planning horizon has been extended to facilitate both the attack of enemy follow on echelons and the synchronization of future operations. While the corps areas of influence, operations and interest are not fixed (being dependent upon METT-T), a corps in Europe may require visibility out to a distance of three hundred kilometers (ninety-six hours) beyond the FLOT. This added depth greatly increases the amount of information that the corps must continually and effectively manage. The Intelligence Preparation of the Battlefield (IPB) effort increases in direct proportion to the amount of terrain within the area of interest. As battle progresses, the corps must obtain coverage over a greatly increased number of enemy units (Figure 4-1). While the routine flow of IPB and and enemy information is through intelligence channels and beyond the scope of this study, the products of the intelligence process are an integral element of the command and control system and must therefore be considered. In order to fight a battle in depth, the corps must be capable of simultaneously attacking enemy follow-on echelons, managing the close-in battle, fighting a rear battle, and detecting potential windows of opportunity for offensive action. To execute these tasks, the command and control system must be capable of focusing on selected critical elements of information on demand. In addition, since depth is also stated in terms of resources, the corps command and control system must be capable of maintaining visibility over all assigned units (to include combat, combat support, and combat service support elements).

AGILITY: Agility, in doctrinal terms, implies speed, flexibility, and precision. Precise measures of effectiveness for these areas have not been developed. In general terms, the requirement is to discern enemy intentions, formulate appropriate plans, and effectively execute those plans before the enemy can carry out his intended action. The goal is frequently stated as "operating within the decision cycle of the enemy." Agility stresses the command and control system in two major areas. First, it demands rapid and efficient information management within the corps headquarters to support planning and decision making. Within the command post, the right information must be provided to the right staff element at the right time. Additionally, all staff elements must be continually appraised of the current situation, planning guidance, and commander's intentions. On the Airland Battlefield, decisions cannot wait until after a periodic staff briefing. Second, agility requires rapid and positive methods for dissemination of information and orders to subordinate organizations. If the corps is to get within the decision cycle of the opposing combined arms army, lag times of up to several hours for hard copy orders with overlays cannot be tolerated.

SYNCHRONIZATION: Synchronized operations are those in which all elements of combat power are focused on the accomplishment of missions which satisfy the intent of the commander. This necessitates wide dissemination of mission type orders, implementing instructions, and the establishment of a common understanding of the commander's intent among subordinate commands. Therefore, greater amounts of information must be provided to both staff elements and subordinate or supporting organizations. Synchronization is more than mere coordination, and efforts to achieve synchronization place great stress on the overall command and control system. An example of synchronization, as it applies to maneuver forces, is presented later in this section.

INITIATIVE: Initiative requires that U.S. forces, instead of reacting to enemy activities, must instead act with speed, precision, and power. Only in that manner can the enemy be forced to assume a reactive mode. Initiative implies that the Army will routinely fight offensive actions at the operational and tactical levels. In offensive operations, which are characterized by speed, mobility and rapid changes in the situation, commanders will frequently control their forces from positions well forward on the battlefield. A corps commander may habitually operate from his TAC-CP. Frequent displacements of the TAC-CP can be anticipated in order to keep pace with advancing maneuver elements or to enhance survivability. Therefore, the command and control system, or at least a portion of the system, must be supported by equipment that is relatively portable, rugged, and capable of being quickly placed into operation following movement.

From the above, the requirements generated by Airland Battle tenets can be summarized as follows:

-Depth greatly increases the amount of information flowing into the command and control system from external sources.

-Synchronization necessitates increased output (or at least more effective output) from the command and control system.

-Agility requires more rapid processing of information within the command post organization and more rapid dissemination of orders to subordinate formations.

-Initiative has a major impact on how the command and control system must be configured.

In addition to an examination of doctrinal requirements, it is also essential that the nature of the battlefield be considered. The Airland Battlefield will be characterized by rapid maneuver of both friendly and enemy forces, increased proliferation of highly lethal weapons systems (many of which will be targeted directly against U.S. tactical command and control), intense electronic warfare, and possible use of chemical and nuclear weapons. The battle will be fought at a rapid tempo with severe and widespread destruction. These characteristics necessitate the development of a flexible, responsive, rugged, and robust command and control system.

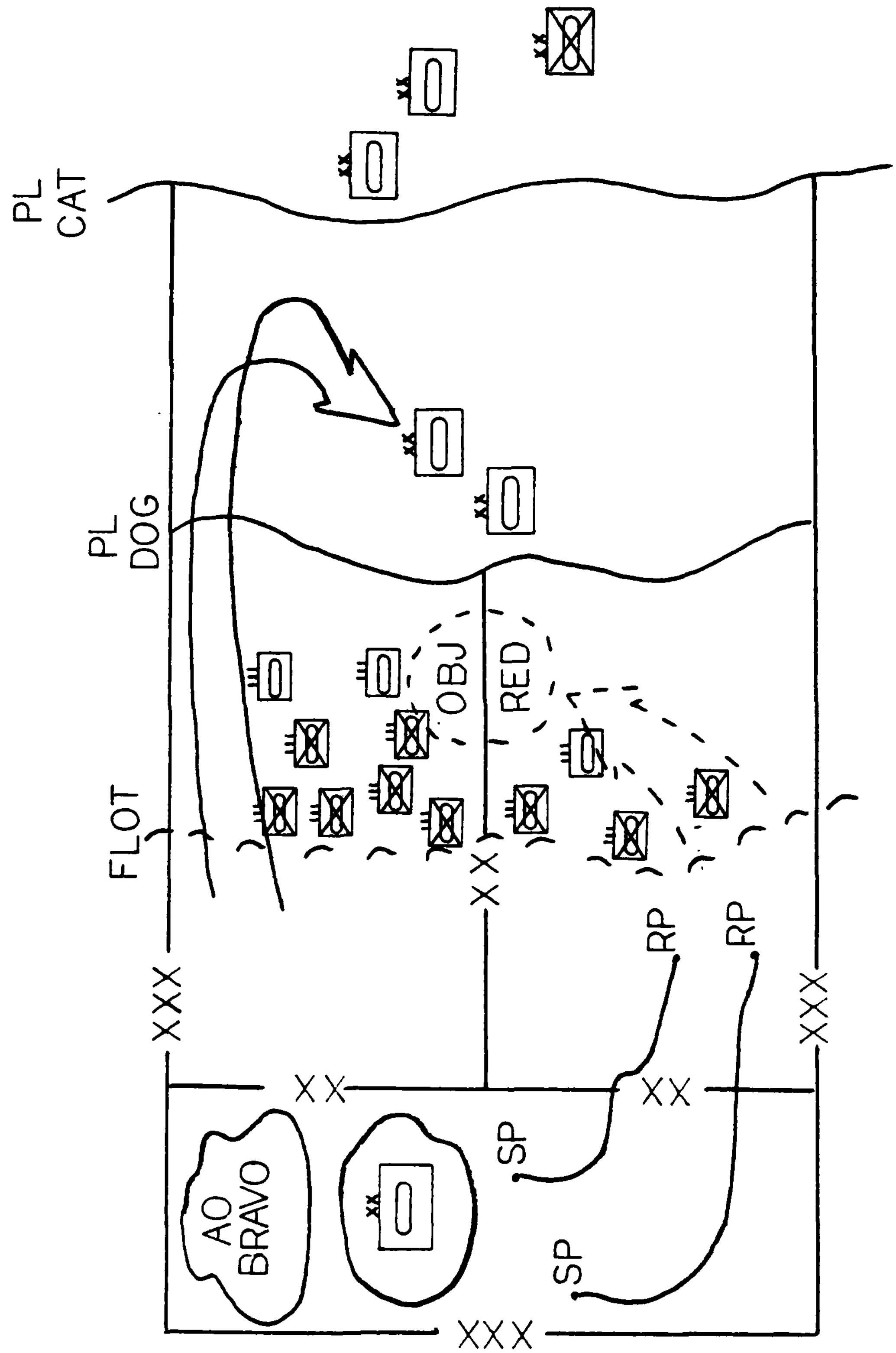
To clarify the impact of doctrinal requirements in an operational environment, the following scenario is presented (refer to the tactical array depicted in Figure 4-1). Situation: A corps is defending in sector with two divisions abreast and one in reserve. The enemy within the corps area of influence consists of a combined arms army of three motorized rifle divisions and two tank divisions. The second echelon of the combined arms army has not yet been committed. Elements of follow-on forces, consisting of tank army with two tank divisions and one motorized rifle division, have just begun to enter the corps area of interest.

1. The corps is managing the close-in battle, which is being fought by its two forward divisions. Within the scope of the term "manage" are included the following functions or activities: monitoring, supporting, directing as required, and allocating resources (both logistical and elements of combat power).

2. The corps is executing a deep attack with its attack helicopter battalion against the 2d echelon tank divisions of the combined arms army. The intent is to take advantage of the enemy disposition (march column) and cause severe attrition within the divisional tank regiments prior to their introduction at the FLOT. In addition, the corps would be closely monitoring intelligence information for indicators concerning possible formation and commitment of an Operational Maneuver Group (OMG). Should an OMG be formed, it would receive priority for deep attack.

3. The corps is controlling a battle currently being fought in the rear area in AO BRAVO. A mechanized battalion is deployed against an estimated enemy battalion which had been inserted by helicopter.

FIGURE 4-1: CORPS IN THE DEFENSE



4. The corps is planning a counterattack to be conducted in approximately eighteen hours in order to destroy the remnants of the enemy combined arms army (which will at that time have had their capabilities significantly degraded by both close combat at the FLOT and by the deep attack). In addition, the corps seeks to gain more favorable terrain for future operations.

5. The corps is focusing its deep collection capability on enemy follow-on forces as they move into the corps area of interest. The intent is to track the enemy movements and determine windows in time and space in which the enemy formations can be attacked with optimum effectiveness. To this end, Named Areas of Interest (NAI) and Target Areas of Interest (TAI) must be developed. The deep attack will initially be executed with Battlefield Air Interdiction (BAI) assets and later with other corps attack assets.

6. The corps is continuously monitoring other friendly and enemy activities within its area of interest.

This tactical scheme, coupled with other elements of combat power (fire support, electronic warfare, air defense, tactical deception, etc) and combat service support, presents a synchronized operation in which the commander, by considering the battlefield in depth and achieving agility in thought and movement, has gained the initiative. The important point to be derived from this scenario is that all actions, although not occurring simultaneously, are simultaneously being processed within the command and control system. This processing is comprised of a continuous spectrum of information inputs, analyses, decisions, and outputs (either directive or informational in nature).

The previous paragraphs have examined the impact of Airland Battle doctrine on the command and control system. In addition, it is necessary to translate that impact into functions, the performance of which can be enhanced by the use of microcomputer systems. The functions which are adaptable for computer support fall into three general categories. These are information distribution, information management, and decision support. Each is defined below. Detailed discussions of each category will be contained in Section II of this chapter.

INFORMATION DISTRIBUTION: Doctrine requires rapid, accurate, and reliable transfer of large amounts of information. Transfer is required between echelons of command and among staff sections or command post nodes within an echelon of command.

INFORMATION MANAGEMENT: Airland Battle doctrine requires corps to process large amounts of information. Included within the category of information management are data storage, retrieval, and manipulation.

DECISION SUPPORT: Rapid and effective decision making is essential on the modern battlefield. Decision making can be enhanced by decision support mechanisms. The category of decision support includes two sub-categories. These are information display techniques and general war fighting applications. Information display techniques encompass the methods by which information is presented to decision makers (either the commander or staff officers). Within the scope of war fighting applications are mathematical routines and algorithms which assist decision makers in performing analysis.

This section has developed the impact of doctrinal tenets on the current command and control system. Doctrinal requirements on the system have been translated into functional processes within the system which can potentially be enhanced by microcomputers. The remainder of the chapter will be devoted to a detailed examination of the processes which have been identified, and to an assessment of the utility of current microcomputer systems in enhancing those processes.

II. C2 SYSTEMS: PERFORMANCE AND POTENTIAL

Recent emphasis within the Army concerning the development of microcomputers for support of tactical command and control presumes that such systems, if properly designed and integrated, can improve operational effectiveness, thereby assisting commanders and staff elements in meeting requirements generated by Airland Battle doctrine. This section will provide an assessment of how well the current systems have performed in that regard. This assessment will be accomplished by further developing the three functional areas (information distribution, information management, and decision support) and examining the performance of the existing microcomputer based systems in each area. Since SPADS, MCS, and AIDS are designed to perform different roles, a direct comparison of overall system performance would be inappropriate Therefore, emphasis has been placed on specific functional utility. In addition, comparisons of capabilities and demonstrated performances are useful as indicators of potential utility for future microcomputer systems. Experiences thus far should therefore provide a sound basis for conclusions and recommendations to be presented in the following chapter.

The Maneuver Control System was formally evaluated by the TRADOC Combined Arms Test Activity (TCATA) in conjunction with REFORGER 1982. SPADS was similarly evaluated by TCATA in conjunction with WINTEX 83. These two evaluations are the major sources for functional performance data described in the remainder of this chapter (unless otherwise noted). No formal evaluation of AIDS has been performed.

A. INFORMATION DISTRIBUTION:

Doctrine, as previously discussed, requires rapid, accurate and reliable transfer of large amounts of information. Transfer is required between echelons of command (corps and division) and among staff sections or command post nodes within an echelon. Computers can support and enhance information transfer by transmitting textual or graphic material as a data stream through existing tactical communications systems. There are several theoretical advantages to computerized data transfer. Material can be stored and manipulated by both sender and recipient. High transmission rates can be achieved, reducing the effective load on existing communications means. Finally, automated routing of information reduces the administrative work load on the command and control organization, allowing more effort to be devoted to planning and analysis. The operating characteristics and functional utility of the three current systems are addressed below.

OPERATING CHARACTERISTICS: Capabilities with regard to information distribution are governed by the operating characteristics of each system. Each system has several advantages and disadvantages when compared to the others. These are contrasted below.

-MCS equipment has demonstrated the capability of transmitting data over both tactical multichannel and FM voice (secure). SPADS and AIDS have thus far transmitted data over only tactical multichannel.

-MCS has achieved a more positive and reliable interface with tactical communications means than either SPADS or AIDS.

-SPADS has the capability to auto-dial through the communications system. Auto-dial permits routing of information to multiple addressees without human intervention. MCS, on the other hand, currently requires that communications be manually effected before the data link is initiated (NOTE: The production model of MCS is programmed to have an auto-dial capability). AIDS remote processors communicate with the central processor via an acoustic coupler and manual dialing is required.

-Both SPADS and MCS have error detection routines incorporated into their software which insure the fidelity of information during transmission. MCS, however, has error correction capability which facilitates data transmission over poorer quality circuits.

UTILITY: In both V Corps and VII Corps microcomputer systems first found utility as communications devices. Both SPADS and MCS were initially used as a method for hard copy text message distribution, circumventing the traditional (and slower) message transmission means. During WINTEX 1983, MCS was used to transmit 9718 messages. During WINTEX 83, 303 documented messages were transmitted via SPADS among V Corps CP modules.(1) Additionally, SPADS was used to transmit over 1400 electronic mail messages among CP modules of V Corps and the 8th Infantry Division during Exercise CARAVAN GUARD IV, May 83.(2) In addition to text, all current systems have the capability to transmit both graphical material and data. Those applications will be discussed under decision support and information management, respectively.

B. INFORMATION MANAGEMENT:

Airland Battle doctrine greatly increases the amount of information which must be managed at the corps command posts. Currently information management is accomplished via manual preparation, filing and processing, a system that slows in direct proportion to the information load. Computers have demonstrated the ability to enhance information management through use of improved preparation

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1. BDM Corporation, "Wintex 83 After Actions Report," (McLean, Virginia: BDM Corporation [1983]), p. I-8.

2. V Corps, "SPADS/Dispersed CP In Progress Review," briefing presented at V Corps Headquarters, May 1983.

techniques, efficient files storage, and flexible retrieval routines.(3) Several functions which fall within this category are addressed below.

WORD PROCESSING: Word processing enhances the preparation of information in text format. First, it is generally considered easier and faster to compose and edit material using word processing software than by previous methods (typewriter or pencil). More important, however, is the fact that word processing effects the entry of information into the computer system. Once entered, the information can be stored, retrieved and revised, distributed electronically, printed on paper, or reviewed on a monitor. Therefore, word processing can improve information management and, at the same, time reduce the administrative burden on the command and control organization. All three current systems have some word processing capability.

-AIDS word processing, essentially a commercial system, has potentially the most utility for general purpose word processing.

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3. See Appendix D for a comparison of manual vs.machine performance in information management.

-SPADS word processing is provided by the Pascal Text Editor which is designed to support Pascal programming. The Text Editor, while limited, has proved adequate for tactical use.

-MCS word processing capability is limited to a number of pre-formatted reports and a free-text option. Free text is the DD-173 Message Form format. This is somewhat restrictive for general purpose, high volume word processing. In addition, the MCS keyboard is non-standard.

INFORMATION STORAGE: Airland Battle doctrine requires the corps to maintain more information than was required under previous doctrine. Microcomputer systems can efficiently store large amounts of information, an alternative to voluminous paper files. Storage capacity of each system is provided below.

-Mass Storage: Each SPADS local area net has a twenty megabyte hard disk which can store an equivalent of approximately ten thousand pages of text. Approximately thirty percent of that space is required for SPADS software storage. The AIDS Central Processor also has a twenty megabyte hard disk, most of which is available for storage. In the MCS, the TCS currently has slightly more than one half megabyte storage. The production TCS will have an eight megabyte hard disk as an integral module.

-Local Storage: All three systems have the capability for local storage of information. SPADS Staff Duty Stations can store information on five and one half inch floppy disks. Each disk can store the equivalent of approximately forty pages of typed text. AIDS Remote Processors can store information locally on eight inch disks, each of which can store approximately six hundred pages of text. The TCT is provided with dual tape cassettes. Each cassette can store the equivalent of approximately four hundred pages of text.

-Video Disk: SPADS has the capability to access information which is stored on a laser video disk. Each laser disk can store approximately 55,000 frames of information. Each frame is the equivalent of one color monitor display. Currently only photographs of maps or terrain are stored on video disks. However, text, graphics, or other photographic information could be stored on a disk. Significantly, information contained on a video disk can only be accessed. No capability currently exists to "write" information to the video disk.

DATA BASE MANAGEMENT: Currently in a typical command post, information is received by voice, transcribed to paper, filed manually, and (when required) retrieved manually. When specific information is required to support planning or decision making, files must be sorted and information collated by hand. Given anticipated increases in information load and the requirement for speed in decision making, such methods will probably prove inadequate on the Airland Battlefield. Microcomputer systems can store large amounts of information (as previously described), and rapidly search, sort, and collate files with great accuracy. Time savings and improvements in accuracy should enhance the effectiveness of the command and control system. Of major benefit is the fact that information, once in the system, can be stored, manipulated, reviewed, updated, or transmitted to other locations via the microcomputers and the communications system. Further, microcomputer systems provide the capability for information from the originator to automatically update data files maintained by the recipient. As an example, a division which updates its brigade unit status file could automatically "dump" its data to the corps MAIN CP. At the corps MAIN CP, the appropriate unit status files could be updated via software without manual intervention. Significantly, data management capabilities have not been fully developed for any of the three current systems.

-AIDS microcomputers can run commercial data management software. However, none have been tested and tactical applications have not been explored.

-The MCS database system has had only limited field testing. It is designed to support G3 functions, including files for the enemy situation, friendly unit status, unit missions, and unit task organization. The system is designed to provide automatic update of the database (Commander's Situation Reports submitted by subordinate organizations automatically update the data files of the higher headquarters).

-The SPADS database is currently configured to support both G2 and G3 functions. Automatic database updates between echelons is within the capability of the system, but has not been tested. The system is relational in that records from several different data files can retrieved by a user-defined relationship. In addition, the SPADS database system can be tailored by the user to support functions other than G2/G3.

C. DECISION SUPPORT:

For clarity purposes within this paper, computer enhancement for decision support has been divided into two sub-categories. These are Information Display Techniques and War Fighting Applications. The methods in which information is presented have been an integral element in the planning and decision making process throughout history. War Fighting Applications, in the form of mathematical models and simulations, are a relatively recent addition to the planning and decision making cycle.

INFORMATION DISPLAY: Information, in order to be utilized, must be presented to the appropriate decision makers (either commanders or staff officers) in an effective format. Currently, the information display most commonly used by decision makers to exercise maneuver control is a paper map with graphic overlay on acetate. The map is frequently supplemented with text reports or graphic charts. A recent innovation in information display is the use of closed circuit television systems to distribute and display information in the map/text/chart format.(4) The weakness of such display systems is that they normally rely upon manual updating and are further dependent upon manual distribution and processing. Computer systems can enhance information display in several ways. First, information can be presented effectively as text or color graphics on video monitors. In addition, query routines can be incorporated which allow rapid access and display of selected information as required. Of major potential impact in Airland Battle execution is the capability of computers to facilitate automatic updating with effective display, thereby reducing the lag between event occurrence and information presentation. As with word processing and and data management, it is important to keep in mind that information available for display is stored within the system. It can therefore be accessed, manipulated, and transmitted as data over the tactical

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4. III Corps, Fort Hood, Texas, currently has the most sophisticated closed circuit TV system for support of tactical command and control.

communications system. Aspects of information display follow:

-Color: MCS has monochrome capability only. Both SPADS and AIDS support color or monochrome display.

-Monitors: Information display is naturally limited by the characteristics of the monitors provided with the system. MCS has an 8.5 inch by 8.5 inch, high resolution monochrome plasma display. It supports both text and graphics. AIDS uses a color monitor, the size of which is variable. Both text and graphics can be displayed. SPADS uses both a monochrome and a color monitor at each station. This configuration supports the simultaneous display of both graphics and text on separate screens. The size of SPADS monitors can also be varied.

-Display Preparation: With MCS, graphic material is prepared by keyboard or joy stick commands. AIDS and SPADS support graphics preparation via keyboard, joystick, and graphics pad (which facilitates accurate free hand drawing). Significantly, none of the systems has software which translates numeric data into graphical format automatically.

-Display Review: With the MCS, files must be individually accessed for review. Both SPADS and AIDS software packages enable the linking of text and graphic files for consecutive display, much like a conventional 35mm slide presentation. The user can review either the entire program or selective portions only. The major difference (for the reviewer) between SPADS and AIDS is that SPADS can display information simultaneously on two monitors.

-Tactical Display: AIDS has no capability to display overlays on a standard map background. Tactical arrays must be displayed as replications on a blank (normally black) background. With the MCS, a paper map, cut to an 8.5 inch square, can be placed behind the plasma screen. The map then serves as a background for overlays which are displayed on the screen. SPADS, with its video disk player and supporting software, provides two types of tactical displays. Photographs of maps which are stored on the video disk can be accessed and displayed on the color monitor. An operator can display units entered in the enemy order of battle and friendly unit data bases as an overlay (using standard military symbology) on the map photo. The user can also create graphics to be displayed as overlays on a map photo. Using keyboard commands (or a joystick) the user can zoom in or out to gain higher map resolution or more area coverage on the monitor display. The user can also pan in cardinal directions, selecting different locations for display. The computer automatically calibrates both database and graphic overlays to the map scale and grid location as the operator zooms and pans. Further, overlays can be routed to a plotter and plotted to-scale on acetate. The acetate can then be used as an overlay for a standard paper map.

WAR FIGHTING APPLICATIONS: A key step in the decision making process is analysis of information. Frequently, if factors which can be quantified are involved (movement speeds, consumption rates, etc), analysis can be supported by simple manual mathematical computation. Microcomputer systems, with appropriate software, can perform such computations with more rapidity and accuracy than manual methods. Usually, however, the arena of tactical maneuver command and control is characterized by analysis which is highly subjective in nature. Decisions are based upon the judgment of key individuals. While microcomputer systems cannot improve upon human judgment, they can provide analytical tools which supports decision making. Some areas which have a potential pay-off for computer enhancement are:

-Wargaming: Appropriate algorithms and the computer allow the planner to wargame possible courses of action. Depending upon the sophistication of the program, the computer can predict costs, flag probable decision points, and highlight critical events. Capability to vary resource constraints and other parameters allows the planner to play "what if" through successive iterations of several courses of action. This refinement process can enhance the final product, in this case a tactical scheme of maneuver. Thus far none of the current systems has been used as a wargaming tool. For that reason, their utility cannot be assessed.

-Analysis: Microcomputer systems can be used as an analytical tool to support planning and decision making. An example of an analytical application can be derived from the tactical scenario presented in section I of this chapter. The corps desires to attack enemy follow-on forces (in this case, the tank divisions of a tank army) soon after they enter the area of operations. The ability of the terrain to support movement can be determined as part of the IPB process prior to the initiation of hostilities. Enemy divisional movement rates can be defined within reasonable parameters, given number and type vehicles, routes, and weather. With appropriate algorithms written into the software, the microcomputer system can analyze the terrain and the enemy and predict potential NAIs and TAIs, thereby supporting the overall corps plan. These types of applications, however, are dependent upon software which has not yet been developed for any of the three current systems. Therefore the potential of AIDS, SPADS, or MCS in this area cannot be assessed.

-Filtering: Given the voluminous amounts of information that must be processed by the corps command and control system, it is essential that appropriate filters be established so that critical information is rapidly surfaced instead of being buried with the mass of less important items. Software can easily be prepared which flags specific events. In addition, if more sophistication is required, a computer support system can be programmed to correlate separate items of information which, when considered together, tend to indicate a critical event has occurred. The system can then initiate the required flags. This type application is dependent upon the development of appropriate software, an action that has not occurred. While all three systems have some inherent potential, their utility cannot be assessed.

-Computation: One of the most obvious applications by which computers can support command and control is as a tool to perform rapid and accurate mathematical computations. As an example, "number crunching" can assist planners in determining the logistic feasibility of courses of action. All three systems, if provided with appropriate software, have the capability to perform mathematical calculations or "spread-sheet" type work. In addition, both AIDS and SPADS have the capability to employ commercial software. Efforts in developing capabilities in this area however, have been minimal. With SPADS there has been some experimentation with the use of Visicalc (TM, Visicorp). This commercial spread-sheet program has been used to support a few administrative and logistical functions.

All three current systems have potential utility in regard to war fighting applications. None, however, have been significantly tested as an analytical tool for support of tactical decision making. Therefore, actual performance or potential cannot be adequately assessed.

III. SUMMARY

In this chapter the requirements placed on the command and control system by Airland Battle doctrine have been examined. These requirements have been translated into functional areas which offer the potential for enhancement by the integration of microcomputer systems. Finally, the performance and potential capability of current microcomputer systems has been assessed for each functional area. To summarize, the major utility of SPADS and MCS has thus far been in the field of information distribution. The major utility of AIDS has been as an information display device. In general, the computer systems have provided a means of timely and accurate information distribution. Some utility has been demonstrated in the area of information management. They have served as data storage devices and as word processors. Database management capabilities have not been fully exploited. In regard to decision support, microcomputer utility has been limited essentially to experimentation with enhancement of information display. Exploitation of war fighting applications has been minimal or nonexistent.

Essentially, current systems present the tactical commander with unrealized potentials. SPADS, AIDS, and MCS have not performed up to their capability. In view of the rapid pace of technology, an increase in the gap between performance and potential can be anticipated. The following chapter will address methods for realizing the potential offered by microcomputer systems.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The assessment which was performed in the previous chapter developed two major points. First, the Army's current doctrine, Airland Battle, generates extensive requirements on the corps command and control system. As discussed in Chapter Four, the system must be capable of processing more information, processing information more rapidly, and enhancing the decision making capabilities of both the staff and the commander. Second, computer systems can assist in satisfying the requirements generated by doctrine. As outlined in Chapter Four, the current systems, MCS, SPADS, and AIDS, are not performing to their full, inherent capability. Primary utility thus far has been in the area of information distribution. Very little utility has been demonstrated in regard to either data management or decision support. In this chapter, conclusions will be drawn from the information previously presented. Finally, recommendations concerning aspects of future microcomputer systems design and integration will be provided. Unless otherwise indicated, conclusions and recommendations reflect the judgment of the author.

I. CONCLUSIONS

The first conclusion to be drawn from the information presented in this thesis is that a valid requirement exists for microcomputer support for command and control at corps level. In fact, microcomputer support is probably essential if corps is to fulfill its doctrinal role. First, it is doubtful that procedures within the current command and control system, based upon manual information processing, will be capable of managing the increased information load on the Airland Battlefield. Second, successful execution of Airland Battle doctrine requires the commander and key staff officers to "think forward," rapidly assessing information, determining courses of action, and issuing directives. These activities can be greatly enhanced by automated decision aids. Finally, microcomputer systems can greatly improve the quality and timeliness of information which must be transmitted between echelons, significantly increasing the capabilities of the corps to control its maneuver forces. As previously cited, Appendix D contains a comparison of man/machine capabilities for functions associated with the decision making cycle.

Second, one can conclude that none of the systems currently being tested in tactical units will be capable of satisfying all the requirements which will be placed upon the command and control system. This conclusion is not surprising, since none of the systems were designed specifically with Airland Battle doctrine as an impetus. The major utility of MCS, when fielded, will be to support the G3 with hard copy inter-echelon message distribution and with operations/planning databases. AIDS can support the command and control process with decision graphics, and (currently) little else. SPADS, a multi-functional system, possesses a wider range of potential capabilities than the other systems, but has had limited operational effectiveness due to both technical and organizational problems.

As a corollary to the preceding conclusion, one can infer that a comprehensive microcomputer based command and control system should be developed.(1) Parameters for such a system will be developed later in this chapter.

Finally, some conclusions must be made concerning

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1. In fact, the Command Post Automated Staff Support System (CPASS), currently under study by CACDA at Fort Leavenworth is a closely related endeavor.

organizational and procedural questions. Although these areas were not specifically examined in the body of the thesis, they have been mentioned peripherally to other material contained in previous chapters or in appendices. They are highly germane to the development and fielding of any future system.

-Development Cycle: The development cycle for microcomputer systems is too long. MCS, realigned under PM OPTADS in 1980, will not be fielded until 1985. SPADS, conceptualized in late 1981, is still in a state of evolution. Should new systems have similar developmental time-lines, it is doubtful if the Army can field a new, comprehensive command and control support system prior to 1990.

-Standardization: The proper balance between flexibility and standardization has not yet been determined. Some degree of standardization is essential for combat effectiveness. Standardization enhances procedural efficiency, training, maintenance, and communications. Some standardization in procedures will be imposed when MCS is fielded throughout the Army in coming years. Currently, however, little standardization exists. MCS, SPADS, and AIDS are not compatible with each other (however, some work is in progress to develop the capability to transfer data between MCS and SPADS devices). Significantly, SPADS configuration in V Corps differs from SPADS configuration in XVIII Airborne Corps. Although standardization is desirable, some flexibility in operational procedures must be retained to support differences in operational environments, changing situations during the course of battle, and to accommodate the desires of the commanders.

-Requirements Definition: Tactical units have had difficulty generating comprehensive functional requirements for command and control support systems. This can, in part, be attributed to a lack of knowledge concerning microcomputer capabilities (and limitations) among tactical commanders and staff officers. Significantly, all three corps considered in this study initially exploited the capabilities of computers to enhance the communications system. Only later did efforts shift to the use of computers for data management or as decision aids, the areas that offer the highest potential pay-offs.

In summary, the conclusions presented above establish a doctrinal requirement, document a shortfall in operational capability, and focus on the problems associated with the development, fielding, and integration of microcomputer systems. The major question remaining concerns <u>how</u> to satisfy the doctrinal requirement. The obvious answer is by developing and fielding an appropriate system in the near term. Observations on various aspects of those topics are presented in the remainder of this chapter.

II. <u>RECOMMENDATIONS</u>

The recommendations derived from the research associated with this thesis fall into two general categories. These are system design issues and organizational issues. Each of these categories is discussed in the following paragraphs.

A. System Design Issues:

In examining system design issues, it is essential to make several assumptions, each of which has a major impact on the resulting recommendations. Since the scope of this thesis is limited to the 1984-1990 time frame, the following assumptions concerning equipment were deemed necessary:

-Equipment could not be fielded via the normal military research, development, and acquisition cycle within the time limits prescribed. Therefore commercial equipment must be used as a basis for any system recommended.

-Equipment must be currently (April 84) commercially available in order to be tested, modified as required, purchased, and fielded prior to 1990.

-Commercial equipment could not be modified to meet full military design specifications within time limitations.

In addition to the assumptions which were driven by time constraints, several other assumptions had to be made. These are:

-Cost is not a significant discriminating factor among existing commercial systems.

-Software applications, if not commercially available, could be developed within the time limits considered in this thesis.

-Additional personnel would not be available to operate or support the system in tactical units.

Given the above assumptions, the next step would logically be to recommend a specific microcomputer system that could enhance tactical command and control and meet the demands of the Airland Battlefield. That, however, is not possible within the scope of this thesis. The complexity of the commercial microcomputer market and rates of change associated with microcomputer technology will make identification and selection of specific items of equipment most difficult. Extensive market research will probably be required to support that endeavor. For this thesis, it is more appropriate to recommend <u>features</u> which should be incorporated into the system. These features have been divided into three categories: General Characteristics; Functional Requirements; and Design Details. Recommended features which fall within each category are described below.

GENERAL CHARACTERISTICS: General characteristics are defined as the basic physical requirements generated by the operational environment (i.e. tactical units on the battlefield), applied to a hypothetical microcomputer system. They are:

-Compatibility: The Army has an existing communications system with planned new equipment fieldings for the future. In addition, MCS will be fielded commencing in 1985. Clearly, compatibility of any commercial microcomputer system with these two is desirable, if not essential. Effective integration of the microcomputer system with MCS and communications systems would enhance the overall effectiveness of the command and control system.

-Expansibility: A feature of current microcomputers is that hardware, without modification, can be used to perform a variety of functions through the use of different applications software. It can be anticipated that new uses for the system will be developed after procurement and fielding have commenced. Therefore, any system designed to support tactical command and control should be capable of expanding in order to satisfy unforeseen requirements as they are developed. Within the scope of expansion are included both increased memory and integration of additional peripheral devices. On most current microcomputers, expansion is facilitated by slots in the interior of the computer which accommodate additional "cards."

-Portability: Given the battlefield environment, a high degree of portability is required. This can be

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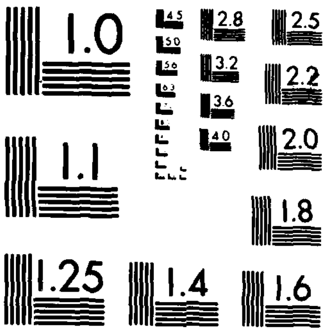

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

achieved via two basic methods. First, the system components can be small and lightweight, facilitating loading, unloading, and transport on unit cargo vehicles. Second, the system components can be designed for rack mounting in tactical command and control vehicles or in standard communications shelters. Actually a combination of both methods may be required for flexibility. As an example, the system components may have to be rack-mounted in M577 tracked command post carriers for the TAC-CP. However, in the MAIN-CP the system may have to be either mounted in vans for operations in remote locales, or unmounted when the CP is configured in buildings.

-Simplicity: The system must be relatively simple to set up and to operate. Training time is at a premium within tactical units. Any requirement for lengthy training sessions to develop and maintain operator proficiency is not desirable. This is particularly true since in many cases the operators may be staff officers (depending upon the function being performed). Further, in light of high personnel turnover rates, particularly during war, increased complexity may result in decreased effectiveness.

-Flexibility: The user should be able to adapt the system to a variety of garrison functions. Unfortunately, at corps level opportunities for tactical training are limited.(2) If the system can only be employed during field training or command post exercises, periodic training sessions must be programmed in order to maintain operator proficiency. If the system is designed so that it can also support normal garrison activities, training requirements are reduced and higher levels of proficiency can be routinely maintained. A second aspect of flexibility relates to system configuration. Any system fielded throughout the Army will have to support several different types of organizations, each of which will have different requirements. Therefore users must be able to tailor the system to meet their needs.

-Reliability: The system must be reliable. If reliability is suspect, tactical users will continue to perform functions manually. Consequently the work load on the staff will increase. This will lead to degradation of operator proficiency which will further reduce operational reliability. In time of crisis, it

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2. This observation is based upon personal experience. In the three years during which I was assigned at V Corps, the Headquarters participated in an average of only five field exercises per year.

is likely that the system would not be used at all.

-Durability: Naturally the system must be reasonably durable. It must be handled by soldiers, transported about the battlefield either on trucks or in tracked vehicles, and subjected to the hazards of combat. Durability, however, can be considered as a broad spectrum. The MCS, designed to military specifications, is extremely durable. The price for that durability is dollar cost, size, weight, and development time. The other end of the spectrum is equipment used in an "off the shelf" condition such as the AIDS microcomputers. While such equipment is relatively inexpensive and can be expeditiously fielded, it is somewhat fragile. A balance between the two extremes can be achieved through several methods. These include either construction of protective packing cases (as with SPADS) or modification of the hardware. Another approach is to issue a judicious amount of spare items of equipment, thereby creating a limited degree of redundancy.

-Maintainability: This is closely associated with durability. Any system which is fielded must be maintainable to a reasonably high operationally ready rate. Like other items of equipment, procedures for operator, direct support, and higher echelons of maintenance must be developed in conjunction with associated levels for spare parts and maintenance training.

FUNCTIONAL REQUIREMENTS: In Chapter Four, functions which could be performed or enhanced by microcomputer systems were delineated as part of the assessment. This paragraph provides recommendations on which functions should be incorporated into future near term systems.

-Message Distribution: The system should support automatic message distribution. The following capabilities should be included: text and graphics transmission; auto-dial through the communications system; multiple addressing; error detection and correction.

-Word Processing: The system snould have word processing capability adequate to support either tactical or garrison requirements. Included within the scope of word processing are both the software features normally associated with the term (formatting, spelling correction, global replace options, etc.) and an adequate keyboard. In addition, capability to merge graphics and text files is desirable.

-Graphics: The system should have a color graphic capability that supports decision graphics displays, including tactical overlays and automatic translation of data files into graphical format.

-Database Management System: The system should have a relational database management system that can satisfy the major requirements of the corps staff, particularly in the operations and intelligence fields. The database management system should be designed with appropriate "filters" so that subordinate organizations, by updating their data, automatically update the data files maintained at higher headquarters.

-Spread Sheet: The system should have a "spread sheet" capability which can support both resource management (including personnel and logistical fields) and forecasting.

-Tactical Display: The system should support a variety of tactical display options, including video disk applications such as those currently developed for SPADS, MICROFIX, and other systems.(3) In addition,

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3. MICROFIX is a microcomputer system (Apple II based) which is designed for Military Intelligence applications.

the system should be capable of supporting displays using a digitized terrain database. Digitized terrain displays, while not widely used to support tactical command and control at present, will probably become more prevalent in the future.

-Decision Support: The system should provide several decision support aids. Graphics and tactical display features have been discussed above. In addition, the system should be capable of "flagging" critical events to the operator as information is processed. As an example, should a subordinate unit indicate a major degradation in operational capability in a BIRS report, that information should be automatically extracted from the database file and routed to the operations and planning staffs. Finally, the system should support the algorithms which facilitate war gaming courses of action, comparison of force ratios, and targeting (among others).

DESIGN DETAILS: Functional requirements drive system design. Translation of the requirements described above into specific items of equipment and software to support command and control is beyond the scope of this thesis (and the qualifications of the author). However, some general observations on the design of a prospective system, based upon information developed during this research, are appropriate.

-Physical Design: In order to provide maximum flexibility and facilitate tailoring, an "unbundled" design is desirable.(4) With an unbundled microcomputer as the basic component, users can be provided with only those items they require, enhancing portability and reducing training requirements, maintenance load, and cost.

-Central Processor Unit: The commercially available "state of the art" microcomputer CPU chip is the Motorola 68000. This chip will be used as the CPU of the production TCT and TCS when they are fielded. Selection and further development of a microcomputer based on the Motorola 68000 will offer several advantages. First, since the chip has greater capability, the performance (operating speed and capacity) of the system will be increased. Second, 68000 based machines, given their capabilities, may prove better able to perform applications which, as of

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4. An unbundled system consists of separate components (i.e. CPU, monitor, disk drives, etc). By contrast, a bundled system has the essential hardware designed within one package.

yet, have not been envisioned. Finally, selection of a 68000 based system may reduce problems associated with interfacing the system with the MCS.

-Monitors: In order to achieve the functional capabilities recommended previously in this chapter, the system should include both color and monochrome monitors. Work stations which function primarily for word processing or data management could be equipped with a monochrome monitor only (reducing cost and increasing portability). Work stations intended to provide decision support could be equipped with a color monitor. Some stations may have to be equipped with both monitors (as SPADS work stations are currently configured). Consideration should be given to fielding a limited number of wide-screen video displays. Currently operational planning and decision making is supported by paper maps. Changing the primary decision aid from map to computer generated display on a monitor has major implications. It has an impact on internal operating procedures and individual training, both of which influence overall operational effectiveness. Incorporation of a limited wide-screen capability may aid in smoothing the transition process. Naturally potential benefits would have to weighed against costs (portability, dollars).

-Power Requirements: The system must be capable of operating with commercial power sources in the United States and overseas, or with power from military generators in a tactical environment.(5) 110/220 Volt, 50/60 hertz switchable equipment is desirable. In addition, the computers and data storage devices should be equipped with limited battery back-up to permit a graceful shut-down in case of power failure.

-MCS Interface: The system should be capable of interfacing with MCS. Ideally, system work stations should be capable of emulating a TCT for data transmission via the MCS. The command and control system of a tactical organization is analogous to the nervous system of a human body.(6) Carrying that

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5. During SPADS testing in Europe, three major problems relating to power were encountered. Voltage drops and spikes in commercial power disrupted local area networks. Effective grounding of expansible vans proved difficult. Consequently, networks with stations in several vans were frequently disrupted. Finally, commercial step-down transformers do not necessarily provide 110/0 voltage across their leads. Instead, 220/110 may be provided.

6. U.S. Army Research Field Unit - Leavenworth, "Guidelines for Automating Command and Control Functions in Field Units," (undated draft), p. 3-2.

analogy a step further, the MCS will probably serve as the spinal column for the command and control of maneuver forces for a considerable length of time. Therefore, a highly effective interface between a commercial micro system and MCS is essential.

-Software Integrity: The microcomputer operating system and core applications software should be established Army-wide. Procedures for the maintenance of software integrity must be implemented. However, users should also be capable of integrating either locally developed programs or applications software purchased from commercial sources.

As previously mentioned, the technical details of computer system engineering are beyond the scope of this thesis. The above recommendations are provided merely to assist in focusing attention on pertinent aspects of any system being considered for Army-wide use.

B. Organizational Issues:

The purpose of this thesis is to determine the utility of microcomputers for tactical command and control in the near term. This presupposes that a system can be developed and fielded during the given time frame. Further, it assumes that the Army will choose to develop and field such a system. Recommendations discussed thus far have been oriented on solving the technical aspects associated with the development of a microcomputer system. However, should the Army choose to field a system for use in the near term, rapid assimilation of the system into the command and control structure of the corps will be necessary. This rapid assimilation will in all likelihood raise organizational issues that will prove more difficult to resolve than technical problems. Recommendations concerning some anticipated issues are developed below.

STANDARDIZATION: As concluded previously in this chapter, some amount of standardization will be required in conjunction with Army-wide fielding of a system. That will require significant change. Currently the corps are pursuing their own command and control enhancement programs. V Corps, VII Corps, and XVIII Airborne Corps have been discussed in the body of this thesis. III Corps at Fort Hood, Texas, is using a closed circuit television system with two-way audio supported by fiberoptics technology to support command and control. The major advantage which currently accrues to the corps is that each has a command and control support system uniquely tailored to its needs. Further, each system is in the field, not on the drawing board. There are several disadvantages, among which are a certain amount of "reinventing the wheel" and the price which each corps must pay when serving as a test bed (measured in additional workload and organizational turmoil). Operational disadvantages of nonstandard systems include problems with communications between adjacent corps, or between division and corps (particularly since a division may be shifted from one corps to another in combat). Determination of the appropriate degree of standardization may prove difficult. Detailed analysis for all options would be lengthy. However, in view of the development time lines for MCS and SPADS, the following recommendations are provided in order to facilitate rapid fielding of an Army-wide system:

- A decision for development and Army-wide fielding of a microcomputer system to support tactical command and control of corps maneuver forces must be made quickly, if the system is to be operational in the field prior to 1990.

- Concurrent with that decision, standardization of the command and control procedures and processes must begin. Essentially, standardized command posts (both massed and dispersed) with associated equipment, SOPs, and information processing procedures must be developed.(7) Naturally some flexibility must be

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7. Some work on standardization of CPs and SOPs is is being conducted by the Staff and Faculty of CGSC, Ft. Leavenworth.

retained. Realistically, an endeavor such as this must be fed from the top down.

-To support the standardized command post, computer system "packages" can be developed as a basis for issue. As an example, each corps might be issued packages for a TAC CP, Operations Center, Plans Cell, All Source Analysis Center, Personnel/Logistics Cell, and Rear Area Operations Center. The packages would be tailored to functional and environmental requirements by varying types and amounts of equipment. Software would remain standard in all packages.

ROLES: Under The Army Command and Control Initiatives Program (TACIP), corps assumed a major active role in the development of command and control systems. The essential step is now to rapidly transition from separate systems under the TACIP umbrella to a single Army-wide system. In that process, the role of TRADOC as the doctrinal developer and requirements generator would remain essentially unchanged.(8) However, some shifts in the roles of tactical units should occur.

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8. Likewise, I would not anticipate any changes in the roles of other Army agencies. For example, the role of DARCOM would be the same as for any other material acquisition.

-TACIP projects have led to the development of a large base of experience with computer systems and have generated great amounts of information applicable to any system considered for Army-wide fielding. This information should facilitate rapid maturation of an Army-wide system without resort to early evolutionary development in a tactical test bed. TACIP initiatives currently in progress should be continued to avoid any reduction in operational capability within tactical units and to prevent loss of experience with computer systems. However, the initiatives currently in progress should be oriented toward validation of concepts and requirements for the future Army-wide system.

-Tactical users should be tasked to specify desired decision support features. Particular emphasis should be devoted to which final products are desired. As an example, a tactical user may desire the computer to test the logistic feasibility of tactical courses of action. That desire would translate into a requirement for algorithms which can analyze courses of action given several variables: scheme of maneuver; threat; anticipated losses; logistic posture; anticipated resupply. The output might be stockage levels by day by class of supply for each course of action. The use of the computer to develop lucrative NAIs and TAIs which was provided in Section II of Chapter Four is another example.

TRAINING: Operator training deficiencies have been noted in almost all evaluation reports for the systems considered in this thesis. Naturally a training package must be developed for the Army-wide system when it is fielded. Anticipating improvements in software in the immediate future, one can expect that a substantial amount of "imbedded training" will be available to compliment formal instruction. As mentioned previously in this chapter, designing the system for garrison applications as well as field use will further enhance skill retention. However, one shortcoming that must be overcome in order to eventually optimize system capabilities is the general ignorance of microcomputer capabilities throughout the Army and reluctance to accept commercial automated systems for tactical applications. In the interim before the system is fielded, several steps can be taken in this area:

-Encourage, or ar least permit, continued proliferation of microcomputers for both tactical and garrison applications throughout the Army. Increased exposure to microcomputers in garrison and during field exercises will facilitate integration of the system which is ultimately fielded.

-Incorporate microcomputer training where possible in the Army schools system. The procurement of SPADS for CGSC TOC exercises and implementation of the Combat Orders, Training and Evaluation System (COTES) in all CGSC classrooms are outstanding examples of programs that can improve computer awareness.(8) Similar projects should be initiated in other military schools, particularly CAS3 and combat arms officer advanced courses.

-The Army should recognize that computer applications are an integral element of the Operations, Plans, Training and Force Development career field (Career Management Field 54). Further, graduate level work in the computer sciences field should be validated as supporting CMF 54. Given the current use of computer systems for command and control, and anticipated increased use in the future, training "operations types" to be experts in automation makes good sense.

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8. COTES is a system of networked Corvus System Concept microcomputers provided in each CGSC classroom. Software facilitates preparation of staff estimates, development of combat orders, and analysis/decision making.

The organizational challenges that will face the Army during the integration of an extensive microcomputer system into the command and control structure will be great. As previously mentioned, organizational issues will probably prove more complex and difficult to resolve than technical problems. The recommendations included in this thesis essentially only "scratch the surface." They do, however, provide a basis for further thought and study.

III. CLOSING STATEMENT

In this thesis, the requirements that will be placed upon the corps command and control system by the Army's Airland Battle doctrine have been developed. These requirements have been translated into specific functions which can be enhanced by the use of microcomputer support systems. Thus, the utility of microcomputers for the command and control of corps maneuver forces has been determined. Further, recommendations concerning system design and system integration have been provided in order to aid in fielding a system prior to 1990.

In conclusion, immediate action is required. In order to have a functional, go-to-war system in the field by 1990, the Army must fully energize a developmental effort. First, the doctrinal community must provide the framework for the corps command and control system of 1990. Concurrently, tacticians must formulate the system applications that are essential to the execution of the Army's doctrinal concept, Airland Battle. Finally, material developers must drive existing technical capabilities to satisfy the future requirements, both functional and environmental. Only through coordinated, expeditious, and forceful action now, will the Army be ready meet the challenges of the battlefield of the future.

APPENDIX A

STAFF PLANNING AND DECISION SUPPORT SYSTEM

1. The Staff Planning and Decision Support System (SPADS) consists of a number of networked commercial microcomputers. The system is currently based upon the Apple II. SPADS is designed to support planning, analysis, and decision making with data management, information distribution, and information display. Details of SPADS hardware and software provided in this Appendix are current as of mid-1983.(1)

2. SPADS hardware consists of a number of functionally tailored stations which are "hard wired" within a CP module to operate as a local area network. Networks from separate modules are interfaced via the tactical communications systems. A description of equipment and typical configuration is provided below. A SPADS network is schematically portrayed in Figure A-1.

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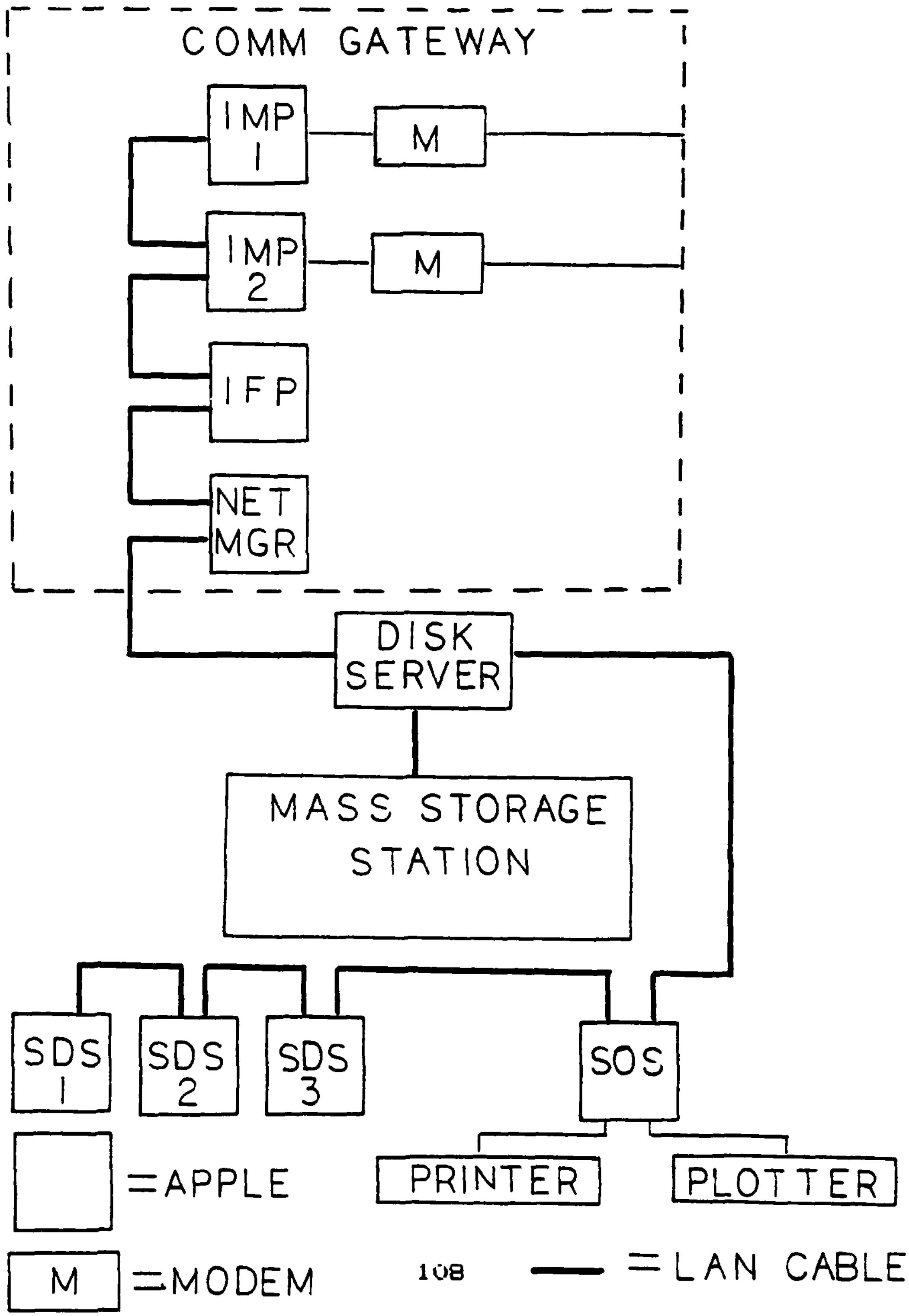
1. Major sources of information in this Appendix are the three SPADS manuals prepared by BDM Corporation under contract to Defense Nuclear Agency. They are, in ascending order of detail, The Staff Officer's Manual, Operator's Manual, and System Manager's Manual.

FIGURE A-1: Typical SPADS local area network.



STAFF DUTY STATION: The Staff Duty Station (SDS) is a microcomputer work station. Each consists of an Apple II computer with two 5 1/4 inch floppy disk drives, color monitor, green/black monitor, and graphics tablet. Some stations are equipped with a high resolution graphics generator and a laser video disk player. Cards within the Apple support USCD Pascal language, 80 column display, and the peripherals. The SDS is the location at which system input or extract information from the system.

SHARED OUTPUT STATION: The Shared Output Station (SOS) consists of a dot matrix printer and an Apple II computer with green/black monitor. The function of the SOS is to provide hard copy output of text and graphics for the module. Material is routed from Staff Duty Stations to the SOS via the local area net. The Apple II at the SOS manages the queue of material for the printer.

MASS STORAGE STATION: The Mass Storage Station (MSS) consists of a Corvus Systems 20 megabyte hard disk, disk server, and video cassette recorder. SPADS software is stored on the hard disk. In addition, storage space is provided for files created by users at Staff Duty Stations. The disk server manages access to the hard disk by other stations on the local area net. The video cassette recorder is used for periodic tape back-up of information stored on the hard disk.

COMMUNICATIONS GATEWAY STATION: The Communications Gateway Station (CGS) is the most complex station within a module. It consists of a number of Apple II computers which perform several distinct functions as described below:

- Network Manager: The Network Manager Apple II controls the local area net. It manages log-ons by users, captures and maintains a record of selected SPADS events, and provides a time-tag to both events and SPADS message traffic.

-Intermodule Processor: The Intermodule Processor (IMP) Apple II processes data being transmitted to another module or data being received from that module. Should a user prepare information at his SDS and direct that it be sent to a user in another module, the information is routed via the local area net to an IMP. The IMP then directs a modem to dial through the communications system, establishes a link with an IMP at the distant module, and transmits the traffic. In a like manner, when traffic is transmitted to a module, it is received by the IMP. The IMP routes the traffic via the local area net to a temporary storage location, called a "pipe", on the hard disk. The message can then be accessed by the appropriate user at his Staff Duty Station. Each CGS can operate up to four IMPs. Therefore SPADS can support simultaneous transmission of information to four separate locations.

-Interfile Processor: The Interfile Processor (IFP) is an Apple II which effects the routing of traffic on the local area net. It routes traffic created at an SDS to the appropriate IMP. It scans the "pipes" and when any traffic is detected, flags the destination SDS. Its software also performs routing of traffic among Staff Duty Stations on the same local area net (which does not involve an IMP). In addition, certain SPADS network "housekeeping" functions are performed by an operator at the IFP station.

3. SPADS was initially fielded to support the development of a modularized, dispersed command post. Therefore, software was designed to support both the commander and the staff when operating in an environment in which opportunities for face-to-face coordination might prove rare. Emphasis has been placed on information transfer and

displav to compensate for the anticipated lack of personal contact. Consequently, data manipulation and files storage and retrieval have been of secondary interest thus far in the SPADS program. A brief description of SPADS software functions follows.

GRAPHICS: SPADS contains a graphics package which allows a user to create color graphics for display on the color monitor of the SDS. Graphics can be created as either backgrounds or overlays. Software permits simultaneous display of a background and an overlay.

WORD PROCESSING: The Pascal Text Editor is used in SPADS for word processing. The Text Editor, designed to support Pascal programming, is relatively limited for extensive word processing.

BRIEFING: SPADS provides the capability for users to prepare material for review at a Staff Duty Station. The user can match text screens, displayed on the green/black monitor, with graphic backgrounds and overlays which are displayed on the color monitor. Text and graphic files can be organized in any desired sequence, constituting a "briefing." The briefing, once prepared, can be reviewed at any SDS on the local area net or transmitted to other modules via the communications gateway. SPADS also provides the capability to link separate briefings for consecutive review.

ELECTRONIC MAIL: Electronic mail is a software package that enables users to send text message traffic to other users either within the module or in other modules via the communications gateway. Formats for messages can be developed if required. Multiple addressees or embedded distribution lists can be used for routing traffic.

DATABASE: The SPADS Database is a relational system that is tailored to support other SPADS functions, specifically the Video Battlefield Display System. Relations in the SPADS Database can be defined by individual users. Currently, however, the major use is the storage of Order of Battle (OB) information for the G2 and Battlefield Information Reporting System (BIRS) information for the G3.

DISTRIBUTED DATABASE: SPADS includes a software package named Common Area Maintenance (CAM) which allows users to distribute the SPADS Database or text and graphic briefings to the mass storage stations in all command post modules. Distribution via execution of the CAM software also permits all SPADS users to access the material.

VIDEO BATTLEFIELD DISPLAY SYSTEM: The Video Battlefield Display System (VBDS) is a software package that matches the video disk player with data stored in the Spads Database OB and BIRS files. Photographs of military maps are stored on the video disk. The user can access a map photo by grid designation and level of resolution desired (i.e. NB4224 by 60 km; NA6780 10 km; etc). The user can zoom in or out and pan in cardinal directions with keyboard commands. On the map photo the user can overlay database information from the OB and BIRS files. BIRS and OB are displayed with standard military symbology. In addition the user can prepare and display graphics overlays showing information such as boundaries, axes of advance, or objectives with a map photo as the background. This information can be distributed to other modules via the communications gateway. As an enhancement to this package, photographs of selected terrain features are also stored on the video disks. These photos can be accessed to assist in operational planning or terrain analysis.

UTILITY SOFTWARE: Utility type software provided with SPADS permits menu abbreviation, copying of files to either floppy disks or print, and direct access data transmission to a staff duty station in another module (via a modem at the local SDS to a modem at the distant SDS).

ENABLING SOFTWARE: A large amount of SPADS software is invisible to the user at the staff duty station, but vital to the operation of the system. This includes the networking software used at the network manager Apple II and the data transfer software used by the IFP and IMP.

4. SPADS developmental efforts are ongoing as part of the Army's Tactical Command and Control Initiatives Program (TACIP). Existing software functions are being refined and enhanced. Equipment is also being upgraded. Apple II computers being used in the Communications Gateway Stations are being replaced with Concept microcomputers made by Corvus Systems. The Concept computers should provide significantly increased computing power and speed.

APPENDIX B

MANEUVER CONTROL SYSTEM

1. The Maneuver Control System consists of fully militarized mini and micro computers which can operate in a stand-alone mode or be interfaced via a variety of tactical communications means. Software is designed to support the tactical commander with data management, information processing and distribution, and tactical information display. The MCS is designed and manufactured by the Librascope Division of The Singer Company. A typical MCS net is schematically portrayed in Figure B-1. Hardware and software are described in the following two paragraphs. Information is current as of the spring of 1983.(1)

2. MCS has three major components, the Tactical Computer System (TCS), the Tactical Computer Terminal (TCT), and the Analyst Console. The TCS and TCT are computers. The Analyst Console is an input/output terminal remoted off of a TCS.

A. The TCS is a militarized, compact, processing, display, and communications system.(2) It is modularly designed.

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1. The major sources of information in this Appendix are brocures prepared by The Singer Company covering the TCS and the TCT, supplemented by an interview with Colonel William S. Kromer, TSM SIGMA, Fort Leavenworth. Where appropriate, they are further cited in notes.

2. U.S. Army, Project Manager CORADCOM. "Tactical Computer System (TCS) AN/UYQ-19 (V)," Librascope Division of The Singer Company) Glendale, California, 1980), p. 2.

Some modules may be selectively omitted, allowing tailoring of the TCS to the operational requirements. All modules are designed to operate in a tactical environment and are protected from moisture, shock, chemical agents, and electromagnetic pulse (EMP). A brief description of the major TCS modules follows:

DISPLAY KEYBOARD: The display keyboard module is the primary point of interface between a user and the TCS. The module has an 8 1/2 inch plasma display which supports either text or monochromatic graphics. Map overlays can be created by inserting a paper map behind the plasma screen and using it as a background for graphics. For operator input the module has an elastomeric keyboard consisting of function keys, graphics control keys, and normal alpha-numeric character keys. An integral joystick is provided to enhance cursor control during graphics preparation.

DIGITAL PROCESSOR AND WORAM MODULE: This module is the central processor to the TCS. The Digital Processor has 64k memory. The WORAM (Word Oriented Random Access Memory) provides an additional 128k memory. Up to four WORAMS can be linked to the Digital Processor of a TCS for a total of 576k memory.

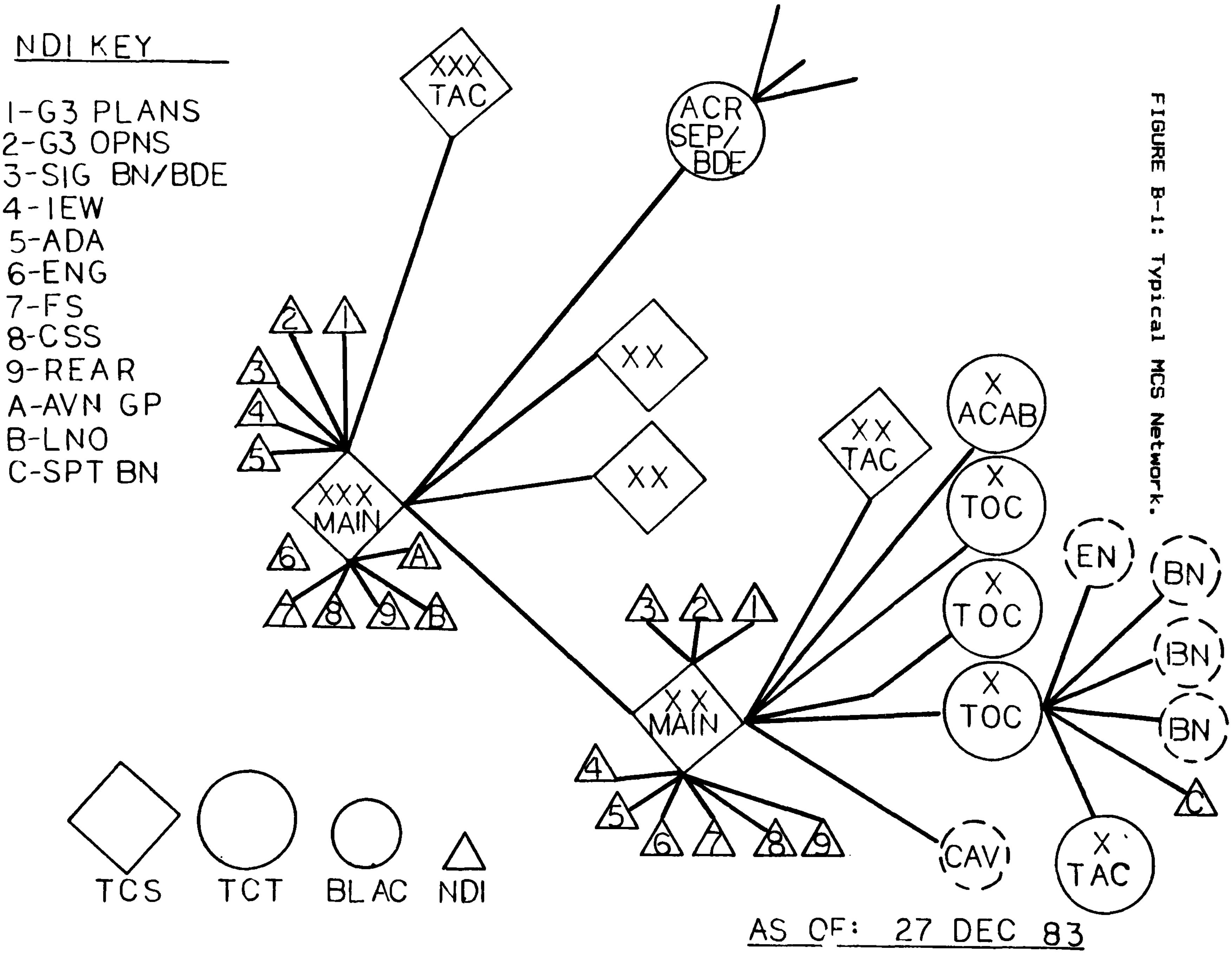
DIGITAL INPUT-OUTPUT INTERFACE MODULE: This module interfaces all TCS modules. In addition it distributes DC power to all modules. It has the capability to service up to five Analyst Consoles which operate off of the TCS.

MAGNETIC TAPE TRANSPORT: Two Magnetic Tape Transports plug into the Digital Input-Output Interface Module. They effect program loading for programs not resident in the WORAM. In addition, one Tape Transport can be used by an operator for local storage of data.

LINE PRINTER-PLOTTER: The Line Printer-Plotter is an 80 column thermal printer-plotter that provides hard copy text and graphics output. It prints text or plots graphics at a speed of 1200 lines per minute.

POWER SUPPLY: The TCS operates on 28 volt DC power. The Power Supply converts 50, 60, or 400 Hertz AC to the required power.

FIGURE B-1: Typical MCS Network.



DIGITAL-VOICE COMMUNICATIONS INTERFACE MODULE: This module provides the interface between the TCS and external systems (TCT or other TCS) over standard tactical communications systems. Data transmission are variable with a low rate of 45.5 bits per second to a high of 32,000 bits per second.

B. The Tactical Computer Terminal is a fully militarized computer terminal which, in external appearance, is very similar to the Display-Keyboard module of the TCS. In the TCT, however, the central processor is self contained, instead of being located in a separate module. The TCT has 96k bytes in Random Access and Read Only Memory (RAM and ROM, respectively). Like the TCS, the TCT has an 8 1/2 inch plasma display screen and an elastomeric keyboard with joystick, function, graphics, and alpha-numeric keys. The TCT interfaces with standard tactical communications systems and transmits data at either 600 or 1200 Baud over voice grade circuits. The TCT can operate a number of peripheral devices including the Printer-Plotter Module of the TCS. A Magnetic Tape Recorder-Reproducer is included with the TCT. It serves as an initial loading device for system programs and for local storage of data.(3)

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3. U.S. Army, Project Manager CORADCOM, "Fully Militarized Tactical Computer Terminal (TCT) AN/UYQ-30," (Librascope Division of The Singer Company, Glendale, California. 1980), p. 3.

C. The Analyst Console is a remote input-output station for the TCS. It consists of a keyboard, display monitor, and printer. It does not have a stand-alone capability.(4)

3. Development is continuing on MCS software, primarily at the CECOM Software Development Center at Fort Leavenworth, Kansas. As part of the evolutionary development process, software is tailored to requirements determined by field evaluation. In addition to its internal operating software, the MCS software falls into four functional categories: communications, graphics, message generation, and database.

COMMUNICATIONS: The communications software enables data to be transmitted over virtually all tactical communications systems, including FM voice using VRC-12 series radios with VINSON secure equipment. Error detection and correction routines incorporated into the communication software permit MCS data transmission over "noisy" circuits without loss of

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4. U.S. Army, Combined Arms Center, "Operational and Organizational Plan for the Maneuver Control System (MCS)," vol. 1: "Executive Summary" (Fort Leavenworth, Kansas: Combined Arms Development Activity, 23 April 1982), p. 1.

fidelity.

GRAPHICS: The graphics capability of the MCS is oriented toward creation of operational and situation overlays. Capabilities include line drawing with keyboard or joystick control, alpha-numerics, and symbols (users can create and store symbols or draw from a library of standard symbols). Overlays, once created, can be stored on tape, plotted, or transmitted to another TCS or TCT.

MESSAGE PREPARATION: MCS word processing capabilities are focused on tactical requirements. Commonly used formats are stored in memory and can be accessed by the user. The "Free Text" option is essentially a standard message format (DD 173, Message Form). Text, once prepared, can be stored locally on tape, printed, or transmitted to other stations.

DATABASE: The database software for the MCS is not yet fully developed. Its operational concept specifies requirements for storage, distribution, and rapid retrieval of critical information in order to enhance performance and improve the survivability of critical functions.(5)

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5. Ibid., p.3.

4. Although production and fielding of the MCS have been approved, product improvement on the system continues. Production models of both TCS and TCT will have enhanced hardware and software features. Further, Congress has directed that non-developmental items (NDI) be incorporated into the MCS. Thus the capabilities and scope of the system in the future will exceed those as described in this Appendix.

APPENDIX C

AUTOMATIC INFORMATION DISTRIBUTION SYSTEM

1. As described in Chapter Three, the Automatic Information Distribution System, AIDS, is used by VII Corps to distribute information within the command and control structure at corps level. The system is based upon commercial microcomputer equipment. Color graphics is the primary method of information display. AIDS was developed as a TACIP project, funded by TRADOC. The following paragraphs describe AIDS hardware and software.(1)

2. AIDS consists of several work stations, termed Remote Processors. These can be netted locally with a Central Processor or operate in a stand-alone mode either locally or at distant command post modules. The Remote Processor and the Central Processor are described below:

REMOTE PROCESSOR: The Remote Processor is a work station consisting of an Intelligence Systems Corporation 8064 microcomputer with either 19 inch or 25 inch color monitor, two 8 inch floppy disk drives, and a digitizer (also called either a bit pad or

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1. Most of the information on AIDS contained in this Appendix resulted from an interview with Mr. John Stucker, project officer for CACDA-C3I. Mr. Stucker, in addition to providing insight based upon his experience, provided several miscellaneous fact documents which described the systems. They are cited where appropriate.

graphics tablet). Some Remote Processors are also equipped with a printer (dot matrix or letter quality) and/or a Hewlitt-Packard 7220 8-pin color plotter. Modems are provided at Remote Processors which are not on the local net in order to facilitate data transfer via tactical communications means.

CENTRAL PROCESSOR: The Central Processor is a Dynabyte Monarch 6600 microcomputer. Like the Remote Processors, it has dual 8 inch disk drives and color monitor. In addition, it includes a 20 megabyte hard disk drive for mass storage. The Central Processor has the capability to interface with 10 Remote Processors or output devices via RS232 ports. These ports facilitate the establishment of local area nets or data transfer with modems.

3. Software provided with AIDS is relatively simple when compared to the two other systems discussed in this paper, SPADS and MCS. AIDS software facilitates preparation of text or graphic material at a Remote Processor, transfer of that information to the mass storage device at the Central Processor, and procedures that enable all Remote Processors to access stored information. Four basic software systems are provided.

OPERATING SYSTEM: The AIDS operating system is in CP/M. AIDS, therefore, can support some other commercial CP/M software.

PROGRAMMING LANGUAGE: Microsoft Basic is provided with AIDS to support local programming capability.

GRAPHICS: Intercolor Graphics System (IGS) is provided to support the preparation and display of information in decision graphics format. Graphics are in high-resolution color. The IGS is proprietary software, belonging to Intercolor.

WORD PROCESSING: Word processing capability for AIDS is provided by a software package named Spectra-Text. Spectra-Text is also proprietary software belonging to Intercolor.(2)

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2. TRADOC Combined Arms Test Activity Letter, "Resume Sheet for CEP 072, VII Corps Tactical Automation Center Automated Information Distribution System (AIDS) Test, 23 February 1982.

4. Formal development of AIDS is essentially complete. However, further refinement of existing applications and development of new applications can be anticipated. These will be dependent upon identification of user requirements and availablity of software.

APPENDIX D

MAN VS. MACHINE COMPARISON

1. The following comparison of performance characteristics for selected functions in the information processing cycle has been extracted from a paper prepared by the Army Research Institute Field Unit - Leavenworth.(1)

INPUT & OUTPUT

PROCESS: Receive, Transmit

MAN UNAIDED BY MACHINE: Communicates mood of sender

MACHINE W/O MAN: Increased effective channel capacity; Hard copy

LEVERAGE (2) Little

PROCESS: Verify

MAN UNAIDED BY MACHINE: Slow; Error prone

MACHINE W/O MAN: Fast; Virtually error-free

LEVERAGE: Little

PROCESS: Input/Output Tag

MAN UNAIDED BY MACHINE: Slow; Error prone

MACHINE W/O MAN: Fast; Virtually error-free

LEVERAGE: Little

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1. Army Research Institute - Leavenworth, "Guidelines for Automating Command and Control Functions in Field Units" (Undated Draft), p. 3-18, 3-19.

2. LEVERAGE is a relative weighting of the complementary effects of man/machine interaction in the performance of the operation.

PRE AND POST DECISION MAKING

PROCESS: Sort

MAN UNAIDED BY MACHINE: Can sort on content; Can generate sorting keys; Slow; Error prone

MACHINE W/O MAN: Can sort only on keys

LEVERAGE: Significant

PROCESS: Associate

MAN UNAIDED BY MACHINE: Can generate algorithms, but slow and error prone at associated operations such as file/post/plot/retrieve

MACHINE W/O MAN: Limited to pre-determined algorithms, but very much faster and error free at associated operations

LEVERAGE: Significant

PROCESS: Aggregate/Organize

MAN UNAIDED BY MACHINE: Can generate algorithms and formats, but slow and error prone at associated operations: file/post/plot/retrieve/calculate

MACHINE W/O MAN: Limited to pre-determined algorithms and formats, but very much faster and error free at associated operations

LEVERAGE: Significant

DECISION

PROCESS: Interpret/Validate

MAN UNAIDED BY MACHINE: Only man can flesh out incomplete patterns and generate new hypotheses and test them

MACHINE W/O MAN: Can only extend human memory (and associated operations) and facilitate hypothesis testing (calculation)

LEVERAGE: Tremendous

PROCESS: Evaluate/Coordinate

MAN UNAIDED BY MACHINE: Only man can interpret in context and generate hypotheses and insights

MACHINE W/O MAN: Can only extend human memory and facilitate coordination based upon a priori rule

LEVERAGE: Tremendous

PROCESS: Project/Extrapolate

MAN UNAIDED BY MACHINE: Only man can define projection and extrapolation parameters; Involves hypothesis generation

MACHINE W/O MAN: Can only extend memory and facilitates calculations

LEVERAGE: Tremendous

PROCESS: <u>Generate Alternatives</u>

MAN UNAIDED BY MACHINE: Only man can generate new hypotheses

MACHINE W/O MAN: Can only extend memory permitting consideration of larger data base; Retrieve a priori alternatives for evaluation; Facilitate rendering in hard copy

LEVERAGE: Tremendous

PROCESS: <u>Evaluate alternatives and decide</u>

MAN UNAIDED BY MACHINE: Man excels at structuring problems to be solved and establishing boundary conditions; Man must make final decision

MACHINE W/O MAN: Can only permit much more rapid calculation with more sophisticated models; Can apply decision criteria more rapidly; Less error

LEVERAGE: Tremendous

2. The information presented above illustrates two key points. First, computers can sort through masses of information more rapidly and more accurately than can humans. In fact, computers can perform such functions with almost no human intervention. Second, human analytic capabilities, when supported by automation, should produce a synergistic effect, speeding the decision making process and improving the quality of decisons which are made.

APPENDIX E

CORPS COMMANDER'S INFORMATION NEEDS

1. The following items were determined to be the corps comander's information needs in the TRADOC Phase I Corps Information Flow Study, 15 April 1979. The material is extracted from Annex A of the Study.

INTELLIGENCE

- Enemy Regimental Avenues of Approach
- Location and Composition of Enemy Nuclear Capable Units
- Location of Enemy 1st Echelon (Regiments and Divisions)
- Location of Enemy 2d Echelon (Divisions, Armies, Fronts)
- Major Enemy Concentrations out to approximately 300 KM from FEBA
- Probable Enemy Course of Action
- Significant Enemy Movement in Past 48 Hours

OPERATIONS

- ADA Coverage Gaps
- ADA Unit Locations
- Current and Projected Status of Roads, Bridges, Railways, Urban Areas, Pipelines, and Airports
- FA Missions
- FA Unit Composition
- Force Ratios
- Major Critical Incidents
- Maneuver and FA Battalion Locations
- Maneuver Task Organization for Combat
- Maneuver Unit Activity and Commander Assessment
- Maneuver Unit Communications Outages
- Nuclear Weapons: Prescribed Nuclear Load
- Reserve Maneuver Unit Identification / Location / Status
- Uncommitted Maneuver Force Identification / Location / Availability
- USAF Sortie Projection / Weather / Comments
- USAF Sorties Requested/Approved
- USAF Sorties Remaining

PERSONNEL / LOGISTICS

- ADA Unit Ammunition Status
- Class III Acceptable Corps Levels
- Class III Levels in COSCOM
- Class V Acceptable Corps Levels
- Class V Levels in COSCOM
- Class VII Operationally Ready
- Class VII On Hand in COSCOM
- Class VII GS Repair Estimate
- Class VII Projected Corps Gains
- FA Unit Class V Status
- FA Firing Unit Status (Crew and Equipment)
- Maneuver Unit Critical Shortages of Class III and V
- Maneuver Unit Weapons Status (Crews and Equipment)
- Uncommitted Maneuver Force Status (Crews and Equipment)

2. The material presented in this Appendix is provided only for general information to the reader. Informational requirements placed upon the command and control system will, in reality, be highly dependent upon the tactical situation, the capabilities of the staff, and the personality of the commander. This list of commander's information needs, while not complete in the opinion of many tactical commanders, was part of a major effort by the

Army to define and quantify information flow within the corps command and control system. Most of the study was devoted to tracking the flow of required items of information through the system. Although the study of information flow is an essential step in the design of an automated command and control support system, it was considered beyond the scope of this thesis and thus omitted. However, the problems associated with management of battlefield information constitute a major challenge facing tactical commanders today.

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